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AGRICULTURE and POPULATION

World Perspectives and Problems

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

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INTERNATIONAL STATISTICAL PROGRAMS CENTER

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World Perspectives and Problems

by Marvin F. Gordon

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PREFACE

The problem posed by rapid population growth and insufficient agricultural production is not one that can be solved quickly or easily. It is a problem that involves a multitude of elements, some of which are obviously and directly related to population and agriculture while others are not so readily apparent. There is, therefore, a tendency to approach a solution by suggesting changes in some of the more obvious elements, attacking the problem in a piecemeal and individual manner rather than instituting a coordinated effort to resolve the overall problem. Agronomists, demographers, statisticians, engineers, ecologists, political scientists, and many others tend to see the problem from the point of view of their particular experiences and formal training. They often disregard work done in other fields because of their specialized perspectives and thus grasp neither the true dimensions of the problem nor the need for coordination of effort.

Since experts engaged in developmental work are usually employed by agencies which often prefer to hire people with similar professional backgrounds, the effort to improve social and economic conditions may become narrowly focused and uncoordinated. Thus, for example, family planning directed primarily at urban areas, however rational the reasons, does not blend closely with the efforts of agronomists to increase farm output in rural areas. Yet, family planning and agricultural production are related, since emigration from rural areas can have a substantial impact on urban growth.

The impact of the narrow focus is also evident in considering solutions to problems within one field alone. To cite some cases in agriculture: the availability of modern farm inputs does not necessarily suggest that they will be used correctly; agrarian reform normally requires something more than mere division of land to be a success; the delivery of water onto the land, by means of an irrigation system, does not automatically maximize yields per hectare. To depend solely upon a miracle strain of rice or wheat to remedy the agricultural situation in some depressed area is comparable to the attempt of alchemists, many years ago, to find a universal cure for disease. This is analogous to modern day attempts to develop larger and faster aircraft without simultaneously planning for improved traffic flow in and around the airports involved. In other words, a crop cannot be considered in isolation from the people who cultivate it and the physical and cultural environment in which it is grown.

It is for the foregoing reason that this study attempts to touch upon a wide variety of subjects as they bear on the problem posed by the population-food gap. In this regard, many questions arise. Why can't agriculture expand into the frontier areas of the world? Why won't the oceans, in the future, supply the world with all the additional food it will need? Wouldn't the problem of low yields be solved if the developing nations used the same amount of fertilizer per hectare as the industrialized nations do? Can't modern science and technology overcome the constraints of the physical environment? Why can't people be induced to concentrate in empty but presumably liveable areas of the world? Can industry be moved into rural areas? What can be done to stop or retard large movements of people from rural to urban areas?

This document cannot supply ready solutions to all these problems. This is in part due to the diversity of conditions within nations; to the inability, at times, of man to master or control certain situations; and to the difficulty involved in accurately determining the direction, magnitude, and impact of future change. The matter is further complicated by the fact that the answers often involve non-technical considerations. As noted, the population-food gap cannot be narrowed solely by the development of a new all-purpose fertilizer or by an improved rainmaking capability. One must also consider the effect of social and cultural institutions, of economic incentives and limitations, of political positions and forces.

It is the intention of this document to help shed some light on the processes and problems involved in dealing with the population-food dilemma. To this end, the relationship between people and their habitat is discussed first. This involves not only the influence of the environment on man, but the technological ability of modern man to control nature. Further, it concerns man's choices of action, actual or imagined, which are apparently open to him within the constraints of a given environmental situation. Second, some of the spatial aspects of population are examined in terms of distribution, growth, migration patterns and settlement. The third chapter, dealing with the characteristics of agriculture, touches upon such varied subjects as agrarian reform, markets, inputs, irrigation, and agricultural development policy. The last chapter is concerned with an examination of population pressure and the possibilities of increasing world food supplies.

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Chapter 1. MAN AND THE LAND

1. INTRODUCTION

The influence of the physical environment on man generally raises certain stereotyped images in the minds of most people. It presumably accounts for the reasons why people live in igloos in the Arctic, grow bananas in the tropics, or wear raincoats when it rains. The converse of this involves the impact of man on his habitat. He can set fire to a forested area, either accidentally or on purpose, and create a prairie; he can change a river's natural path; he can build huge shelterbelts; he can drain swamps; he can cause the salinity of a soil to increase rapidly.

It is often difficult to determine the extent of the impact of man on his physical surroundings and vice versa. Do people grow bananas because the climate is favorable, or because they are good to eat, or because they have a ready market? Where does one influence begin and the other end?

An additional complication is involved in attempting to deal with this subject. Man's response to environmental constraints depends to a degree on his perspective--how he sees things in relation to each other. A differentiation should therefore be made between the actual environment and what man perceives it to be. The Dust Bowl in the United States was created because people erroneously believed that certain portions of the Great Plains could be cultivated, although nature knew better.

This chapter discusses the interaction of man and his natural environment at some length. The first sections deal with the relationship between people and their habitat. The physical components of the landscape--landforms, climate, soil, vegetation, drainage--are discussed in the next sections of the chapter. The final segment concerns itself with environmental perception and man's management of his habitat.

2. MAN-NATURE RELATIONSHIP

The attitudes regarding the complicated man-nature relationship are dynamic, changing over time. For example, it was once customary to assume that man's activities were controlled almost completely by his habitat. With rapid scientific and technological advances, it subsequently appeared to observers as though modern man (as differentiated from aboriginal or primitive man) could free himself from the confining limitations imposed by nature. Within recent times, environmentalists have suggested that modern man's capability to change and pollute his habitat harmfully place realistic restrictions on his eventual freedom of action and range of operations.

Those persons who attempted to explain man solely in terms of the influence of the physical factor were known as environmental determinists, or "sun worshippers." Some followers of this idea have even suggested that people's attitudes and characteristics were the result of physical conditions. Thus, one could explain laziness as a result of high temperatures, or the selection of certain crops solely on the basis of the length of the growing season or soil affinity. Some advocates even suggested that crime rates, or certain matrimonial customs, could be explained on the basis of habitat influence.

Man does not live in a vacuum; therefore, the physical environment unquestionably has some influence upon him. The error of the determinists lay in concentrating upon only a few characteristics

of the immediate environment to explain man's life, activities, and customs. Some examples may help clarify this point. The prevalence of a successful dairy industry around the North Sea cannot be explained solely in terms of the climate, which happens to be a favorable one for dairy cattle. If such were the case, people in other areas of the world with identical climates also would engage in dairying. They often do not. The explanation, in part, must therefore rest upon the effect of the location. The successful North Sea dairy industry is centered in a nearby favorable market area, which has a large urban population with high living standards. Similarly, the United States Corn Belt is located in a part of the country whose climate, soils, and slope conditions can accommodate many different types of agriculture. That the region is used as it is must be partially a result of the influence of transportation conditions, technological skills of farmers, and the purchasing power and desires of distant consumers. In another culture or economy, the Corn Belt might be used in a totally different way. In other words, the effect of man's immediate physical surroundings cannot explain totally his attitudes, customs, or use of the land. One must look beyond this location, or site, and examine the influence of outside forces and areas.

Those who support the idea that modern man is master of his environment point to his ability to make the deserts bloom, to make the Northlands more habitable, or to land on the moon. Nevertheless, there are restraining influences; the economic factor looms large in this regard. For example, if man could level completely a mountain chain, he would still have to obtain the funds needed to do the job. Similarly, claim was made a number of years ago that man could grow potatoes at the North Pole if he so wished.[1] Perhaps this is possible. Nevertheless, considering the per unit cost of production and the expense of transportation to market, the price for the potatoes probably would be unreasonably high.

Ecologists also have indicated the dangers to the environment from an uncontrolled technology. Killer smogs and river pollution readily come to mind.

The net result of all these arguments is to suggest that modern man is not a completely free agent operating within his habitat.

Some geographers have maintained that, given an environmental situation which definitely does restrict man's activities to differing degrees, certain choices of action are open to him. Presumably, this would explain why some people are much more successful in adapting to their environment than are others. One can visualize two farms, located side by side, in similar physical surroundings; one is obviously prosperous and the other is not. The explanation for this might have to depend (for the most part) on the influences, the attitudes, and the activities of man, rather than on nature. Similarly, it has been suggested that cultural factors account for the fact that land-use management by Spaniards in Valencia is much more successful than that of their farmer counterparts in Andalusia, which has a similar physical landscape.[2] To cite further examples, the Great Vale of Chile and the Central Valley of California are physically very similar. They are, however, used very differently; that this is so can be accounted for only in part by the factor of location. Another observer, noting the successes of Japanese farmers in Amazonia, suggests that man "is not condemned to poverty because of the land on which he works or because of the climate, or any other elements of the habitat. He is condemned to poverty because of his own attitudes, objectives, and knowledge of technology."[3] Finally, a governor of French Guiana, in comparing development in his colony in 1770 with that of the neighboring Dutch, had this to say: "The Dutch have, two hundred and fifty miles from us, a flourishing colony. Same soil, same climate, same products; everything is

[1] H.P. Smolka. "The Economic Development of the Soviet Arctic," *Geographical Journal*, Vol. LXXXIX (April 1937), p. 335.

[2] R.E. Crist. "Rice Culture in Spain," *Scientific Monthly*, Vol. 84 (February 1957), passim.

[3] P.E. James, *Latin America*, Fourth Edition (New York: Odyssey Press, 1969), p. 851.

the same except the plans and the means of instituting them. These are two equivalent sites, on which an intelligent architect and an ignorant laborer have built, at the same expense, the one a magnificent palace, the other a miserable hovel."[4]

3. *COMPONENTS OF THE PHYSICAL ENVIRONMENT*

There are five major components of the physical landscape. Man has not mastered complete control over them, nor does he always live in harmony with them. Accordingly, agricultural activities are very much dependent on nature and often involve ecological misuse of the land. This section attempts to describe the pertinent characteristics of landforms, climates, soils, vegetation, and drainage.

3.1 Landforms: constraints of slope

Agricultural production is closely tied to slope. Steep inclines tend to have thin and stony soils; whereas flat areas seem to have better soils, all things being equal. This is not meant to suggest, however, that all flat areas or bottomlands are of high quality, or that sloping land is always poor and unusable. Fruit trees and grapevines are often found on slopes, for example, since this type of location may be less likely to be affected by frost. By contrast, plains may have unfavorable drainage, climate, or soils.

There are four major types of landforms, but a generally prosperous agriculture is associated with only one of them--plains. The other three--plateaus, hills, and mountains--also may have some agricultural areas of high quality, but these are often relatively small in area and less productive and accessible.

3.11 Plains.--Plains, with the lowest local relief (inequalities of land surface), may range from flat to rolling terrain. Like the Gran Chaco of Argentina, or the Great Plains of the United States, they may be found in the interiors of land masses as well as along coasts. Some of the best agricultural regions in the world are located on plains, such as the Indo-Gangetic Plain of India, Pakistan, and Bangladesh; the West European Plain; the North China Plain; and the Ukraine. There are many exceptions, however. Some plains, such as the Amazon or West Siberian, are sparsely settled and not intensively used for agricultural purposes.

3.12 Plateaus.--Plateau surfaces may be fairly flat, depending upon the degree to which the forces of erosion have cut up the land. Nevertheless, local relief can be considerable, since rivers may have cut deep trenches or valleys below the upper surface. These can create transportation barriers and discourage the general mixing of people, goods, and ideas. Isolation thus tends to be a characteristic of the cultures and economies of these regions. Finally, agriculture on plateaus is often restricted by danger of frost or by dryness. The Bolivian Altiplano and the Tibetan Plateau are examples of areas with frost problems. The Spanish Meseta and Patagonian Plateau of Argentina can be mentioned as typical of dry or arid types of plateaus.

3.13 Hills and mountains.--Hills and mountains have similar origins. The former are less rugged, since they are older and the forces of erosion have had much more time to work on them. Hills are consequently lower in elevation; their slopes are gentler and valley floors are wider. For these reasons, hill lands are used to a greater degree for agriculture than are mountainous zones. Nevertheless, good bottom or flat land in hill country may be hard to find. Also, it is difficult to transport bulky goods in hilly terrain, and large markets may be far removed from production centers. In the hill country of the United States, one type of response to the problems posed by slope and transportation is the conversion of corn from a low-value bulky solid state to that of a low-volume high-value product, corn whiskey.

Like plateaus, there is generally less mixing of people in hill lands than on plains. As a result, the fragmentation of population into small and differing cultural and political groups is a common practice in the hill lands.

[4] P.V. Malouet, as quoted in David Lowenthal. "Population Contrasts in the Guianas," *Geographic Review*, Vol. 50 (January 1960), p. 45.

Mountainous areas, with a high percentage of steep slopes, have fewer people and less agricultural space than hills. Population and farming tend to concentrate in highland basins, where some flat land may be found. A very sizable proportion of the population in the Andes is located in isolated pockets of this type.

3.2 Climatic controls

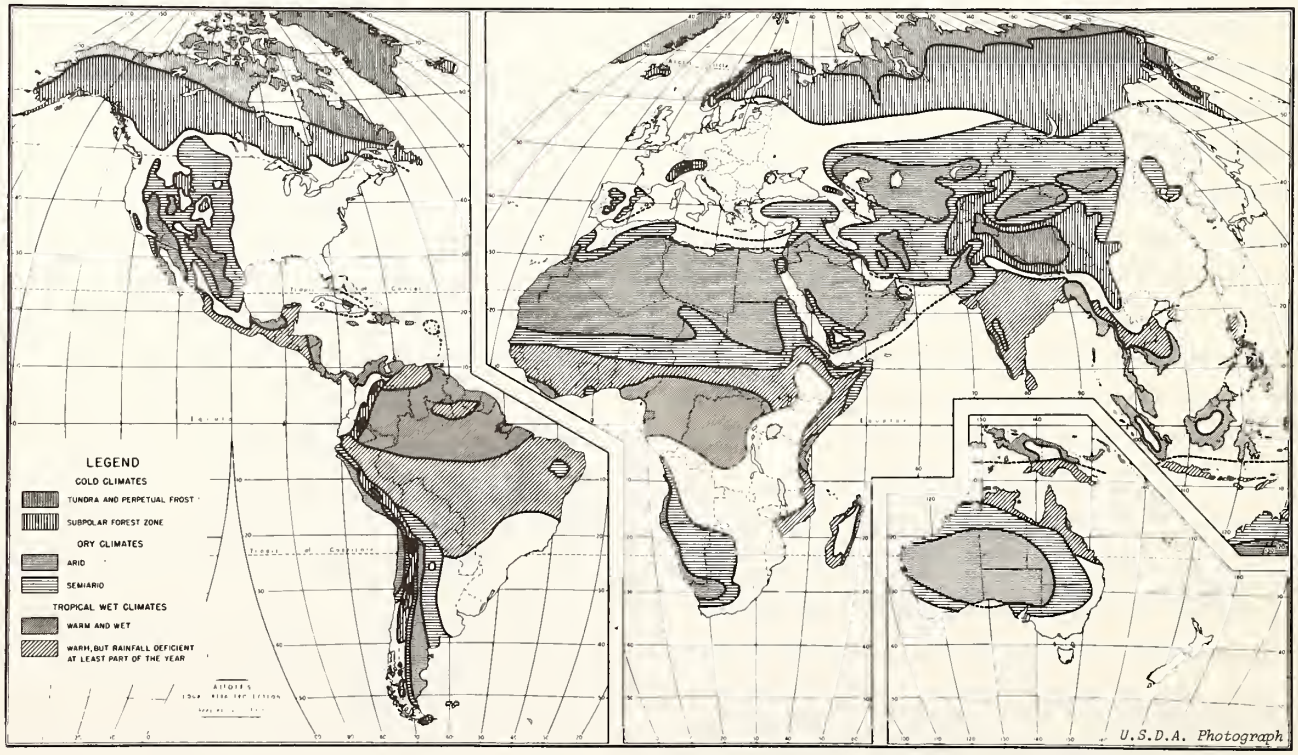
In many countries it has been possible for agriculture to combat the effects of poor soils or steep slopes. On the other hand, it has proven to be very difficult to change the climate or to escape its influence, although some attempts to do this have been made.

The basic components of climate which are of major interest to agriculture are (a) temperature and (b) precipitation. Additional data on evaporation and transpiration are becoming available for many parts of the world and these provide important information. Figure 1-1 shows various climates of the earth that are unfavorable to settlement by most peoples.

3.21 Temperature characteristics and effects.--Air temperature varies horizontally and vertically. In the case of the former situation, changes occur when an air mass over an area is replaced by one which has different characteristics. Temperature changes also occur with increasing elevation; usually, the higher the elevation the lower the temperature. Below are some temperature characteristics that can affect agriculture.

(1) The effect of water bodies is significant. Land tends to cool off or heat up to a greater degree and with greater speed than adjacent water bodies. As a result, weather over water bodies tends to be somewhat milder, and these conditions are often carried onto shoreline areas. Thus, there are some fruit growing areas around certain Great Lakes shores in the United States, where the prevailing winds blow onto the land. These areas have longer growing seasons and fewer frost problems at critical early and late periods in the agricultural cycle, than do surrounding areas. For somewhat similar reasons, small ribbons of agriculture are to be found around Lake Titicaca on the Bolivian Altiplano. Western Europe has a milder climate for agriculture than would normally be found at that latitude, due to the modifying influences of the air masses which blow off the Atlantic onto the land.

Figure 1-1. CLIMATES OF THE EARTH, SHOWING EXTENT OF REGIONS DOMINATED BY COLD, DRY, AND WET CLIMATES UNFAVORABLE TO SETTLEMENT



Source: Climate and Man. U.S. Department of Agriculture Yearbook. 1941.

(2) Cold air may condition location of agricultural land. It is heavy and sinks; evening and early morning frosts are therefore often associated with valley bottoms. Hence, orchards and vineyards are frequently found on slopes above valley floors.

(3) Surface air temperatures are closely related to latitudes. The sun is more effective at heating the earth's surface for longer periods of time in the equatorial (low) rather than in the polar (high) latitudes. Hence, the duration of the growing season changes inversely with latitude, all things being equal.

(4) Altitude exerts an impact on temperature and agriculture. With increasing elevations, there are found climate, vegetation, and soil types which are somewhat similar to those encountered in moving poleward from the equator. Thus, in equatorial Latin America, one finds in successive order up from sea level, the Tierra Caliente (hot land), the Tierra Templada (temperate land), and the Tierra Fria (cold land). The kind of agriculture practiced in each zone is strongly influenced by climate. It should also be pointed out, however, that many variables can condition mountain climates: exposure to sun, prevailing wind, shape of terrain, elevation, etc. Hence, types of agriculture in mountainous areas can differ greatly within short distances.

(5) The temperature range is significant. The range represents the difference between the highest and lowest temperatures during a daily or monthly period. Conditions are more favorable for agriculture if the temperature range is somewhat narrow, from moderate to high. Thus, places with large monthly ranges (such as some Siberian stations) or large daily ranges (such as occur in some desert areas) may present problems for certain types of crops.

3.22 Critical role of precipitation.--Water is critical for life processes. If it is not available through precipitation, surface flow, snow melt, irrigation, or from subsurface sources, life cannot survive. The three significant characteristics in regard to precipitation are total amount, seasonal distribution, and reliability. World climate regions are partly determined on the basis of these criteria. Precipitation zones can be classified as deserts, semi-arid areas, places with alternating wet-dry seasons, and humid regions.

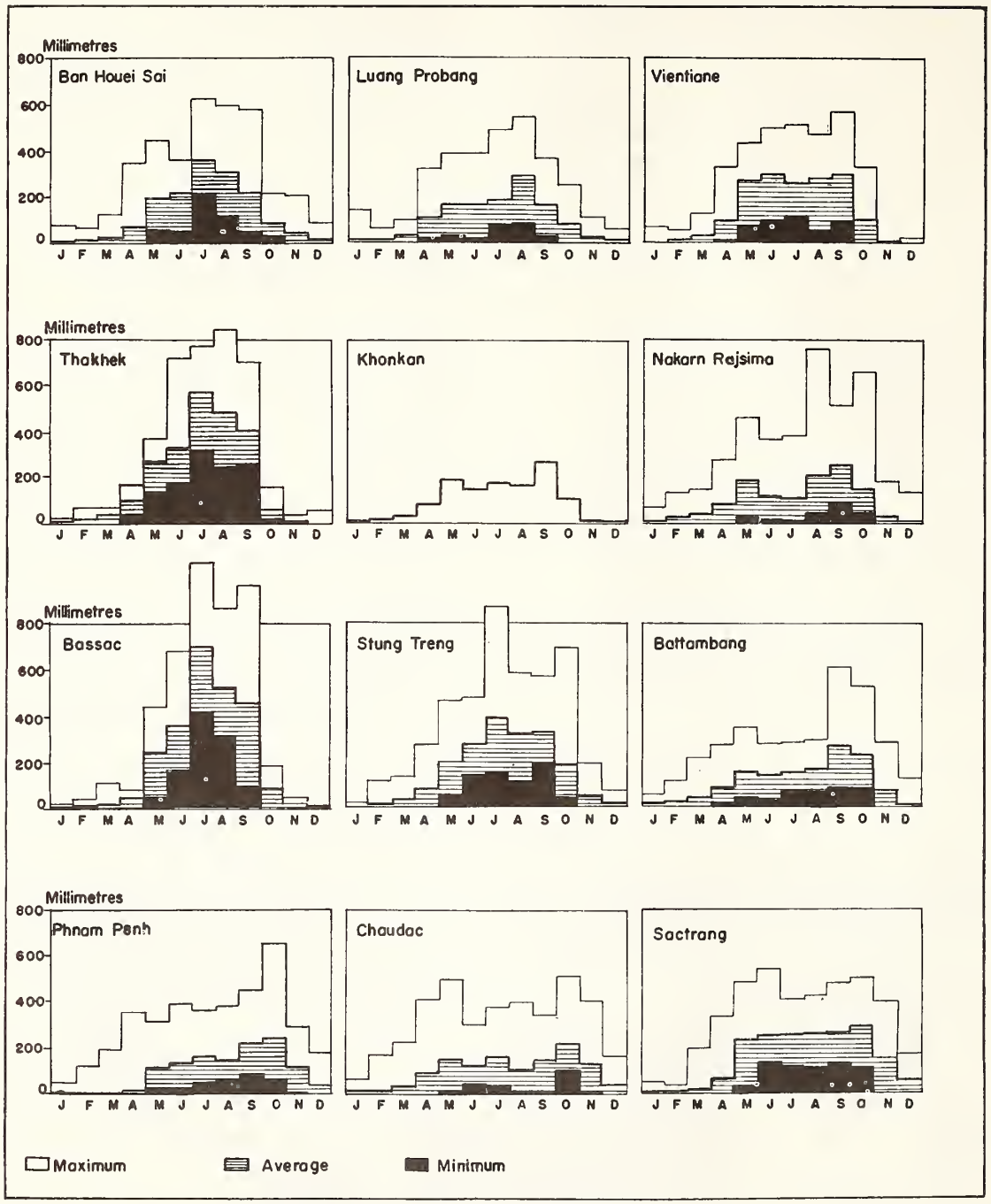
The deserts of the world have low and irregular precipitation patterns. Surface water is extremely limited and agriculture must rely on oases or on irrigation using water from the subsurface or from distant sources.

The semi-arid areas, on the edges of deserts, are often cultivated, but precipitation is unreliable. Thus, an area may experience one year or a series of years of above average wet weather, whereas alternate years or series of years may be quite dry. During periods of drought, there is considerable suffering and unrest. Some of the invasions of peoples from Central Asia into southern and eastern Asia have taken place during prolonged dry periods. The Great Wall of China was constructed to stop those invasions; the Wall tends to follow the 400-millimeter rainfall line and it includes most cultivated areas within its confines. In at least one particular case, however, the Wall was built into the Ordos Desert, beyond the 400-millimeter rainfall line. Since this enclosed a region for livestock grazing, it eventually became a trouble spot and was abandoned; a new wall segment was then built in the south which conformed roughly to the 400-millimeter rainfall line.

Climates which have alternating wet and dry periods often have problems similar to those of the semi-arid zones. Whether it be the monsoons of Asia or the Mediterranean climate, one of the seasons may be much drier or wetter, or of longer or shorter duration than anticipated. Thus, rainfall may vary greatly from the average. (See figure 1-2.) Great damage to the environment can occur if people are tempted to overstock the land, cultivate it, or use it intensively during the green or rainy years.

The humid areas of the world do not face problems of this kind. Even so, droughts occur in some humid places. For example, the northeastern part of the United States suffered from a 5-year period of below average precipitation in the 1960's. At the other extreme, some areas may suffer from an excess of moisture, so that drainage becomes a major problem, and waterlogging of soils can drown crops.

Figure 1-2. MONTHLY RAINFALL AT SELECTED STATIONS IN THE MEKONG BASIN IN SOUTHEAST ASIA



Source: Flood Control Series No. 12. United Nations ST/ECAFE/SER.F/12. Bangkok, 1957.

3.23 Evapotranspiration.--Since crops obtain needed moisture from the earth, the soil can be considered a storage bank in which deposits and withdrawals are made. Precipitation adds water to the soil; moisture is removed by surface runoff, evaporation, and transpiration of vegetation. The impact of transpiration--the giving off of moisture by plants--is not always recognized. Crops may transpire up to several hundred times the weight of the dry matter that they produce. Similarly, the transpiration rate of the water hyacinth, which now covers an extensive part of the Nam Phong reservoir

in northeast Thailand, is over three times greater than the evaporation rate of open water.

Evapotranspiration data are based on estimates of water deficit or surplus in the soil during the year. With this knowledge, farmers are in a better position to know when crops are in need of additional moisture. This is particularly useful information if water, via irrigation, is available upon demand.

Figure 1-3 illustrates evapotranspiration for two typical stations. Station A is in an area with wet and dry seasons; Station B is in a humid region. The solid line (symbol 1) represents evapotranspiration and the dashed line (symbol 2) represents precipitation. Symbol 3 represents a period of surplus precipitation and consequent water runoff. Symbol 4 shows a period of moisture deficiency; it will be noted that this is fairly intensive and occurs over an extended period of time at Station A. Symbol 5 indicates a drain on the soil moisture bank, since evapotranspiration rates exceed the amount of precipitation. Symbol 6 represents a period in which moisture is again being stored in the soil, although there are still insufficient amounts available; accordingly, there is no runoff of water.

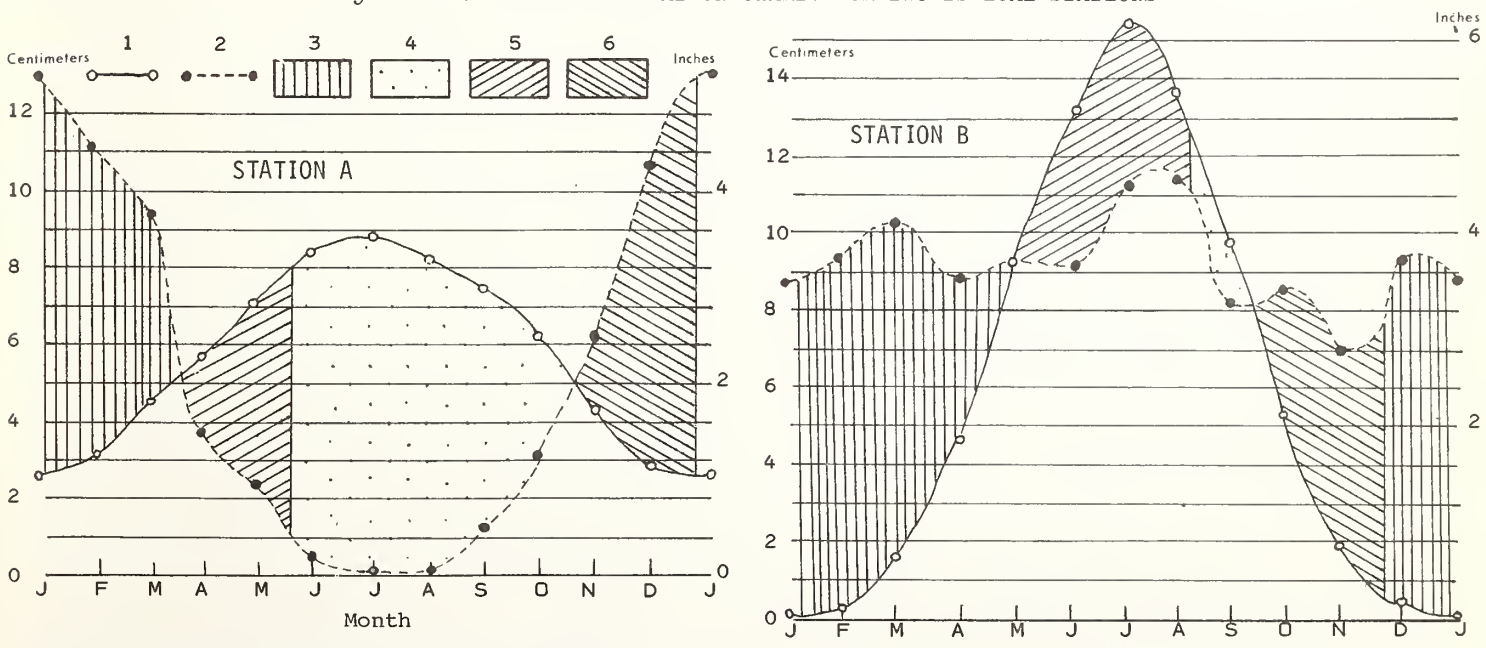
Plants vary in terms of the amounts of water needed, the time when water should be available for use, and the ability of the plants to obtain water from the soil. The introduction of alfalfa as a fodder crop into the Argentine Pampas was largely based on the latter consideration; alfalfa roots could seek water sources far below those which could be reached by native grasses. This adaptation of crops to soil moisture provided the basis for a successful beef industry.

3.3 Soils: processes and types

Soil science is fairly new, dating back less than a century. Knowledge of soil processes and characteristics outside the mid-latitudes, furthermore, is only now beginning to be explored in depth. Along with the new information that is available on tropical soils has come the recognition that even primitive people, given their available inputs, may be excellent farmers who draw upon generations of practical experience and expertise. Thus attitudes and knowledge are undergoing change as soil science starts to explore the tropics to a greater degree than ever before.

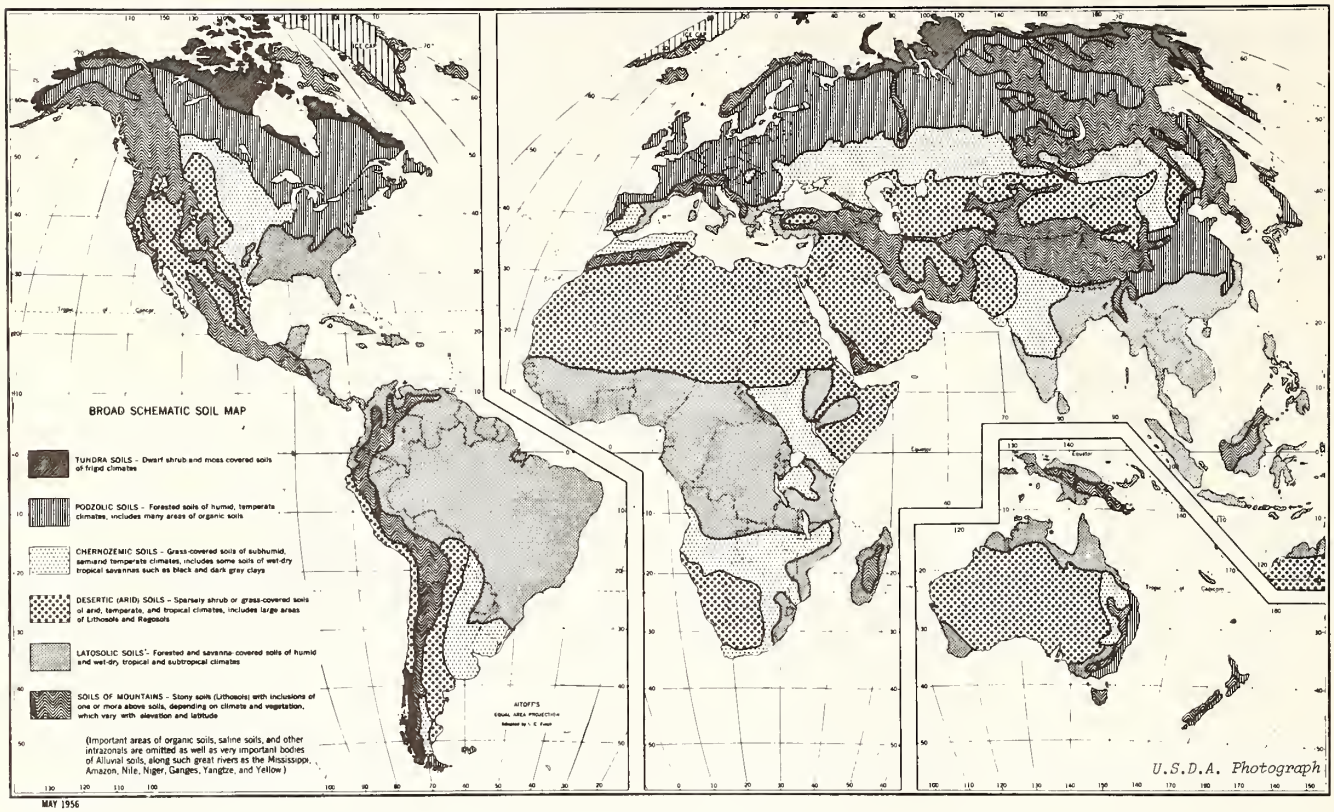
The importance of soil can vary a great deal, depending upon the crop. For example, some plants

Figure 1-3. EVAPOTRANSPIRATION CHARTS FOR TWO TYPICAL STATIONS



Source: Water. U.S. Department of Agriculture Yearbook. 1955.

Figure 1-4. MAP OF THE WORLD SHOWING SIX BROAD SOIL ZONES



Source: Soil. U.S. Department of Agriculture Yearbook. 1957.

grow best only in certain types of soils; this obviously restricts the area where such products can be grown. Certain tobacco and grape crops fall in this category. Basmati (aromatic) rice is another such product; it can only be grown in India and Bangladesh, because of soil requirements. On the other hand, other plants are much more tolerant of soil type. Thus, in parts of Western Europe, particularly because of farm inputs, it might be said that the soil is merely a medium used to hold plants upright. This is an exaggeration, but it does highlight the exceptions noted above. Similarly, it might be pointed out that paddy yields in east and south Asia are not always closely linked to soil fertility, but rather to farming techniques and various kinds of inputs.

Figure 1-4 shows six broad soil zones of the world. Each zone has a different process at work which develops its particular type of soil. However, some zones have similar soils; this is a result of certain local and strong influencing factors, such as poor drainage or steep slopes.

The development of world soil zones is the result of three major soil processes; (a) podsolization, (b) laterization, and (c) calcification. Podsolization is associated with cool to cold humid climates. Podsol soils are acidic. They are found mainly in the middle latitudes and in sub-polar regions. Soils in the middle latitudes can be fairly productive, given proper treatment.

The second process is laterization. Latosol soils are formed under humid conditions and high temperatures and are associated with the tropical regions of the world. These soils have most plant nutrients removed, but they contain large amounts of iron and aluminum oxides. The lush vegetation of the tropics is thus not always supported by rich soil. Rather, it is a result of the large amounts of sunlight and precipitation available, and the ability of plants to absorb the nutrients from decayed material quickly, before they are dissolved

and removed from the soil. Crop yields can be high, however, if soils are properly managed.

The last process, calcification, takes place in arid and semi-arid areas. Calcified soils range from those which are strongly alkaline and poor for cultivation to very fertile and productive types, such as the black-earth type.

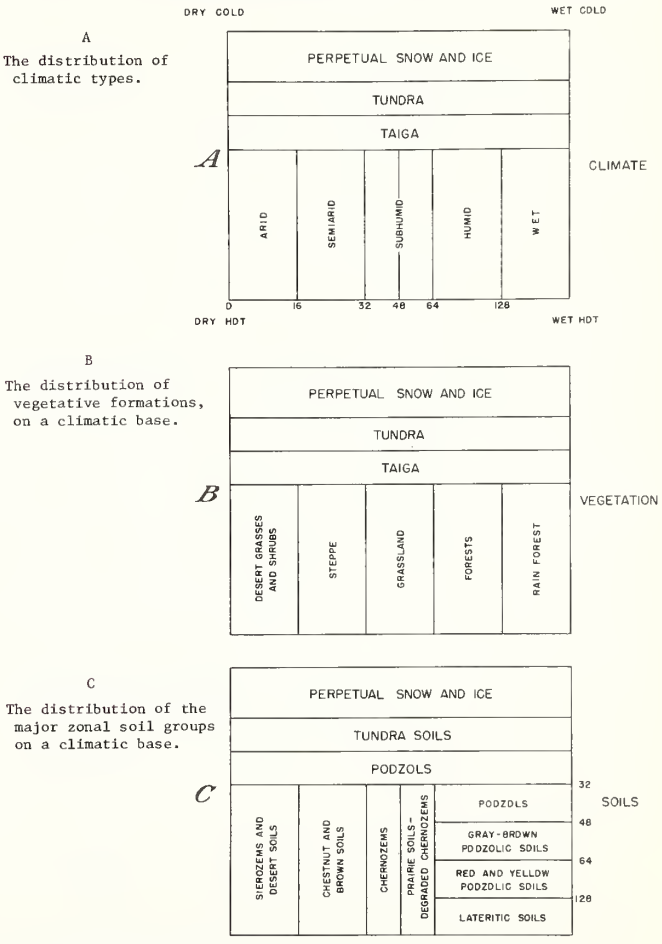
3.4 Vegetation: zones and uses

If nature were allowed to develop the vegetation of a region without intervention by man, a relatively stable plant cover would finally emerge. This is referred to as climax vegetation. The schematic diagram below (figure 1-5) shows a close relationship between climate, vegetative zones, and soils. The vegetative zones that are indicated would consist of climax types. In some areas of the world, such as parts of Western Europe, the United States Mid-West, or East Asia, man has so changed the cover that there is presently little evidence remaining of what the climax originally looked like.

Vegetation can be divided into three major groups--forest, grasslands, and desert shrub. Vegetation zones coincide closely with climate and soil zones.

Generally, forests are found in areas with 500 or more millimeters of rainfall, or the equivalent. There are three types of forest. The selva, or tropical rainforest, is characterized by an abundance of rich vegetation and a great variety of plant species. For this reason it is expensive to locate and transport wood logs of commercial size and specific type. Movement of people, machinery, and wood logs is also often hindered by poor drainage, lack of roads, labor shortages, and jungle conditions in certain areas. The Ford Company rubber plantation along the Tapajos River in the Amazon was unsuccessful in combatting these problems about three decades ago. Currently, some experimental attempts are being made to grow mahogany on a commercial basis in Honduras and other countries. Nevertheless, the commercial future of the tropical rainforest is still in doubt. By contrast, the mixed forests of the mid-latitudes are commercially prized, often because of easier accessibility and the tendency for a species to grow in solid or pure stands (that is, not mixed with any other species). The forest comprises hardwoods and coniferous (cone bearing) trees. The northern forest, consisting of coniferous trees, is known as the taiga. The growing season is short and the trees grow slowly. The frozen ground (permafrost) which thaws in the summer time complicates the problem of movement in the area. Despite this, the southern edge of the forest is used fairly intensively for certain commercial purposes in some places.

Figure 1-5. SCHEMATIC REPRESENTATION OF CLIMATIC TYPES, VEGETATIVE FORMATIONS, AND SOIL GROUPS



Source: Climate and Man. U.S. Department of Agriculture Yearbook. 1941.

Grasslands are located in areas which often have under 500 millimeters of rainfall. There are two types, one of which is found in the tropics and the other in the mid-latitudes. The tropical type (savanna) contains grass which is not rich

in nutrients. Thus, it is not a very desirable grazing area, particularly during certain seasons of the year. The mid-latitude grassland is divided into short grass and tall grass types, known as steppe and prairie, respectively. Precipitation is the major determinant of these forms of climax; the steppe is found in areas which receive less moisture than the prairie. It is not always clear, however, why forests have not developed on the humid sides of prairies, where precipitation is often greater than 500 millimeters. It seems only a partial explanation of a suggestion that aboriginal peoples burned over very large areas for hunting purposes. This occurred on comparatively small tracts of land, however. For example, the U.S. Civil War Battle of the Wilderness was fought in the mid-19th Century in a thickly wooded forest. That forest had been a prairie when settlers drove the Indians away from the area over 150 years before. Major parts of the Argentine Pampas and the Manchurian Plain also seem to have been burned over in the same way. Nevertheless, it is difficult to see how primitive peoples could have had the capability to burn over such extensive areas as the prairies.

Prairie lands are very fertile and are used for agriculture in a variety of ways. The steppe, by contrast, is a marginal zone for farming, due to the prevailing semi-arid climate and the fact that precipitation is unreliable. Despite this, soils can be rich, and wheat cultivation is possible under special conditions in certain areas. Grazing appears to represent the most reasonable type of land use for the greater part of the steppe, although overstocking of the range always presents problems.

Desert vegetation is adapted to climate in a variety of ways. Plants tend to be fleshy, in order to store water; thick bark or a waxy leaf coating cuts down on transpiration loss; long tap roots seek subsurface sources of moisture; plants are widely spaced, so they do not have to compete for such water as is available. Most of this vegetation, however, has little commercial value.

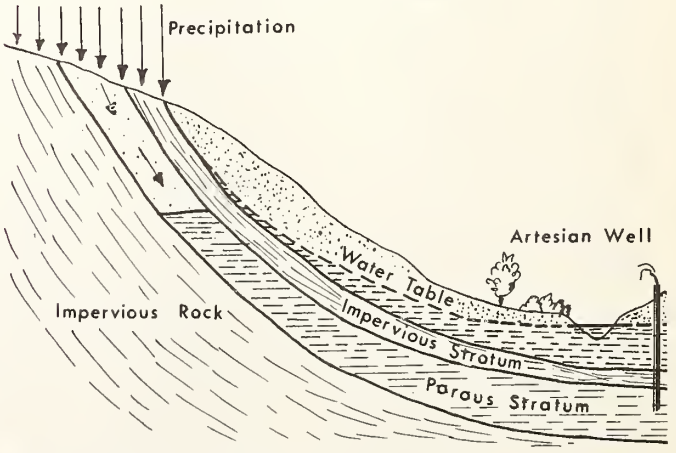
3.5 Drainage systems

Water is distributed both on and below the surface. The latter, referred to as ground water, is stored in porous rock. The top of the zone saturated by ground water is called the water table. It fluctuates according to use and season and appears at the surface in springs, lakes, and along parts of streams. The amount available for use depends upon the storage capacity of the rock and the rate of replacement. In some cases, water is retained in rock strata for very long periods of time. Large ground water sources discovered in Libya and in the New Valley in Egypt possibly date back to the last glacial period.

Ground water can be pumped to the surface from wells. Artesian flow also involves wells, but pumping is normally unnecessary, as the great amount of pressure forces water toward the surface. Artesian wells may be several hundred miles from the catchment area, where the water is caught and enters into the ground (see figure 1-6).

Large artesian basins are found in a number of places in the world, such as Australia and the Great Plains of the United States. One of the major problems of these basins is overuse and the depletion of the water bank. In coastal areas, excessive use will not only lower the water table, but will allow salt water to flow into the ground water source.

Figure 1-6. ARTESIAN FLOW



Source: Water. U.S. Department of Agriculture Yearbook. 1955.

Surface flow involves water in streams of varying sizes and in water impoundments such as lakes. Generally, a flow pattern emerges, so that one can refer to watersheds in which the movement of water is directed from all areas toward the mouth of the main stream.

The lower part of the master stream, near base or sea level, tends to develop flood plains in which the river temporarily deposits the eroded material from the upper part of the basin. Deltas are made up of the same material dumped by the river at its mouth. The alluvium, or stream deposits of both flood plains and deltas, is often fertile and cultivatable. The problem involved in the use of these areas is that of flooding; man has not as yet succeeded in completely safeguarding areas where floods tend to occur.

4. *THE ENVIRONMENT: PERCEPTION, HAZARDS, MANAGEMENT*

It has been pointed out that man does not always see the environment as it is, but rather as he supposes it is. Thus, he may lay plans to alter or to manage his environment, or he may react to a specific ecological situation without knowing the true state of affairs. The results can be something less than favorable.

4.1 Perception and reality

Jim Bridger, a famous U.S. trapper and explorer, met a group of Mormons, a religious sect, advancing toward the Great Salt Lake area some 100 years ago. He lost $1,000 in betting that they could never grow crops in that arid region. The location of their proposed settlement was in an area crossed by many pioneers traveling westward. Like Bridger, most pioneers could see only a desert environment which could not be used or managed successfully by individual farmers. The Mormons, on the other hand, saw an area which could be irrigated by communal (or cooperative), rather than individual effort. Accordingly, perception through different cultural lenses resulted in non-use of the land by one person, and intensive and successful use by the others.

Similarly, the Soviets viewed their virgin lands of Kazakhstan as particularly favorable for wheat cultivation. Nature did not perceive the situation in quite the same light. As one observer noted, "Unfortunately, the virgin turned out to be a harlot in disguise."[5] The project was not a resounding success.

The Arabian advance into North Africa in the Seventh and Eighth Centuries can be cited as a final example of perception. The Arabs at that time migrated northward to Iberia and southward across the Sahara. To persons not familiar with deserts, such areas might be seen as forbidding, but such was not the case for the Arabs who were familiar with problems posed by aridity. One of the reasons why the drive across the Sahara eventually stopped was that a new and unfamiliar environment was encountered south of the desert. This was the northern edge of the tropical rainforest.

4.2 Recognition of hazards

There are a great many examples of true and faulty perception. Some of the more critical problems in this connection involve hazards.

The reaction of people to environmental danger depends upon the magnitude and frequency of the hazard. Infrequent and minor damage will not normally generate a vigorous response. Conversely, the possibilities of countermeasures being taken are better if great damage is incurred frequently.

Hazards may be man-made as well as natural, but some are difficult to assign to any single force. For example, the damaging impact of a drought may be increased by man's misuse of the environment; lack of proper land-use controls on a flood plain can substantially increase the amount of destruction which occurs. Major hazards include floods, storms, droughts, frost, fire, pollution, and erosion.[6]

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[5] P.R. Ehrlich, and A.H. Ehrlich. *Population, Resources, Environment* (San Francisco, California: W.H. Freeman & Co., 1970), p. 92.

[6] Earth movement is not included in this study because of its comparatively minor impact on agriculture.

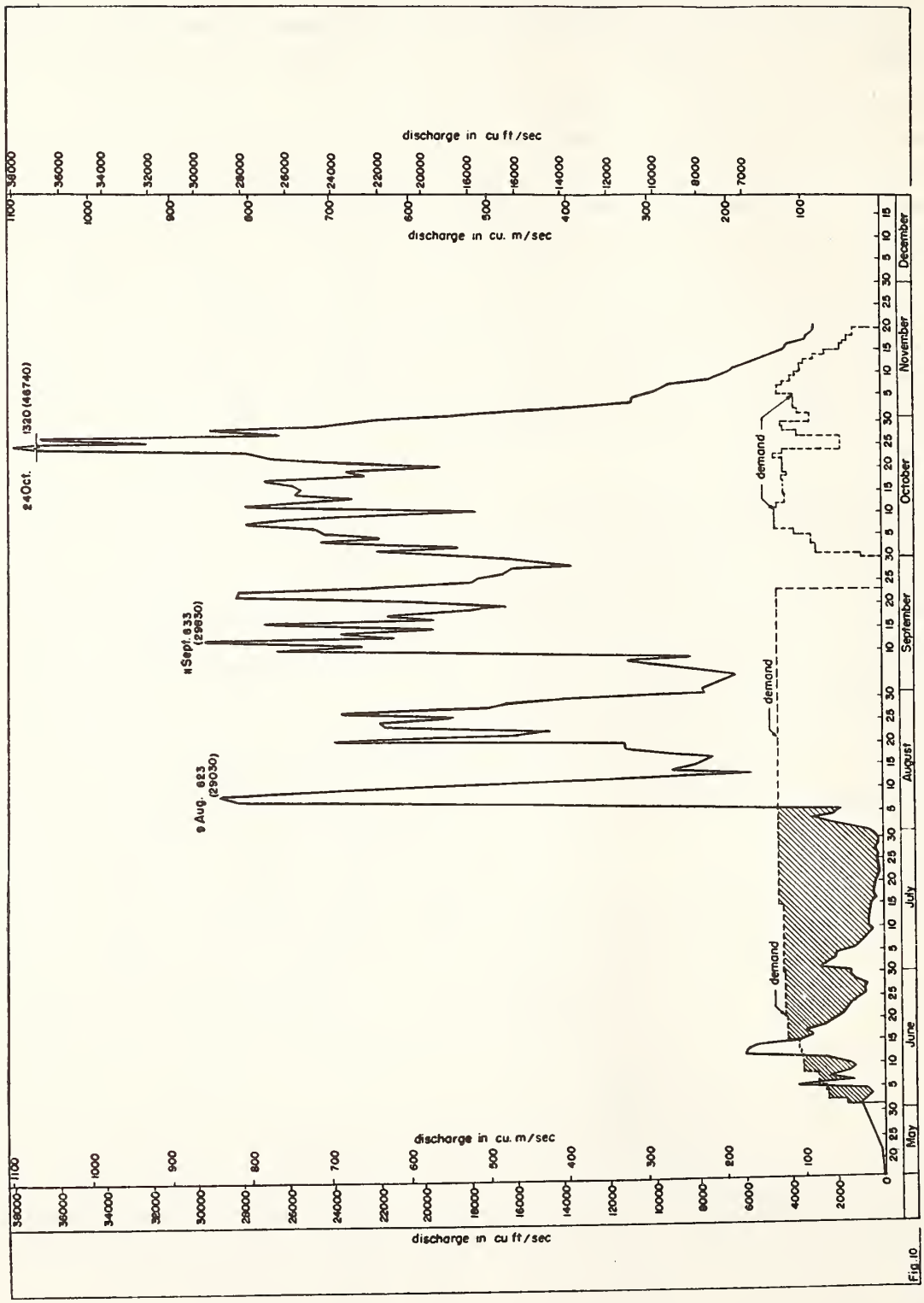


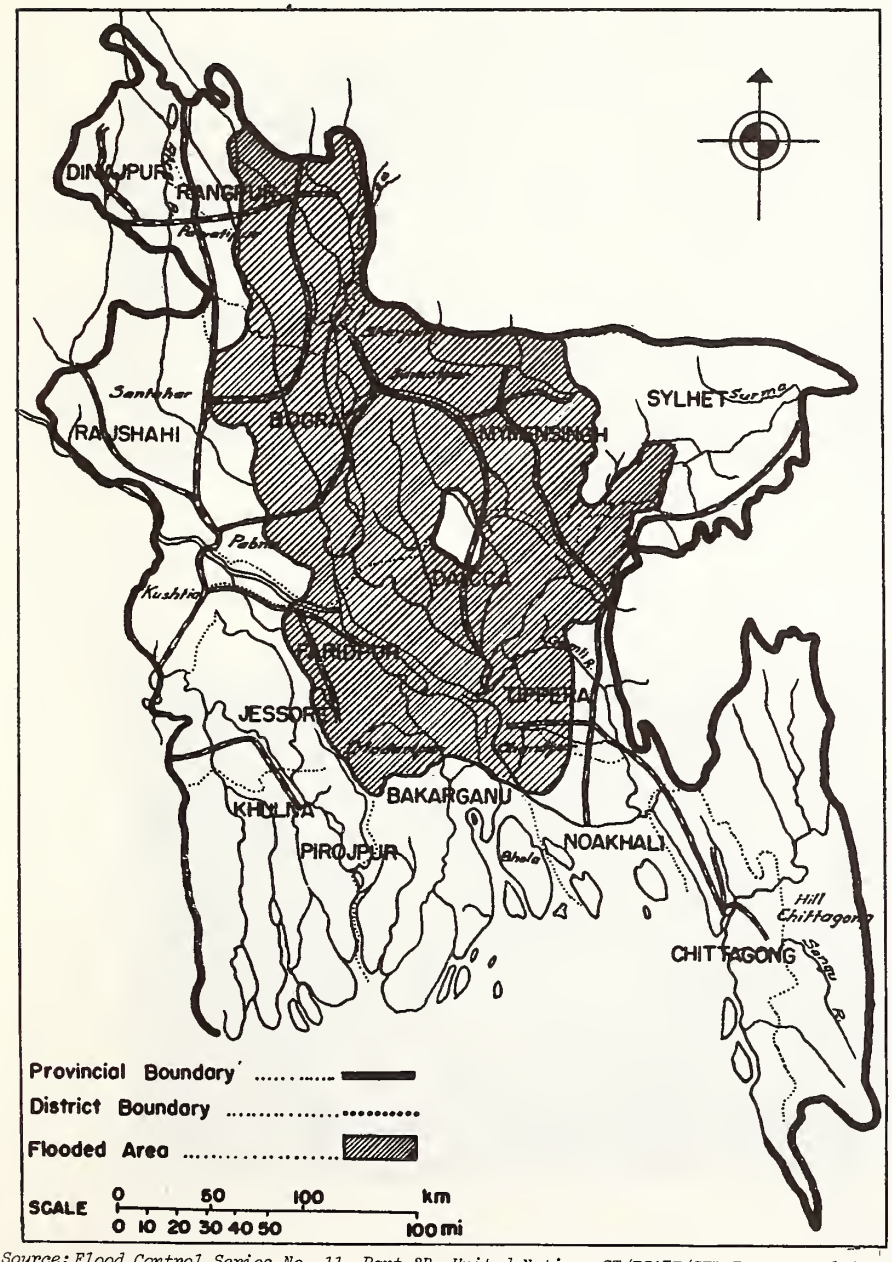
Figure 1-7. DAILY HYDROGRAPH OF MU RIVER AT KABO: 1947

Source: Flood Control Series No. 11. Part 2B. United Nations ST/ECAFE/SER.F/11. Bangkok, 1956.

4.21 Flooding.--Flooding occurs mainly in deltas and along flood plains. The amount of water flowing in rivers can vary tremendously at different times of the year or from year to year. (See figure 1-7 on the opposite page.)

Although populations since early times have tried to combat flooding, the degree of success has been limited. This is due in part to the fact that people do not normally perceive a river basin as an integral physical unit. Thus, administrative boundaries often follow the master stream, and attempts may be made to alter the flow in one area without considering the impact elsewhere in the watershed.

Figure 1-8. MAP SHOWING GENERAL AREA OF 1954 FLOOD IN BANGLADESH



Source: Flood Control Series No. 11. Part 2B. United Nations ST/ECAFE/SER.F.11. Bangkok, 1956.

Coastal damage is particularly great as a result of strong cyclonic activity and hurricanes or typhoons. Wave action and flooding often result in loss of life and destruction of housing, crops, and animals. Nevertheless, many deltas such as those of the Ganges, Indus, Nile, Hwang Ho, and Mekong Rivers are intensively used, even though they are open to storm attack because of their very low relief. For example, a strong cyclonic storm and a great upsurging of sea water from the Bay of Bengal in 1970 drowned thousands of persons and caused a great deal of property damage as well. This occurrence was not unique. The region is fairly flat, and the delta lies along the paths of cyclonic tracks. Eight damaging storms have hit the same area during the decade of the 1960's. Figure 1-8 shows the area affected by a major flood in 1954.

4.22 Drought.--It has been noted that semi-arid regions are particularly susceptible to prolonged drought. The danger to these areas is created by farmers who, during the wet green years, are willing to gamble on cultivation and on ranchers who are tempted to overstock the range. This removes the climax vegetation and lays the dry topsoil open to erosion. In the area illustrated in figure 1-9 (on the following page), removal of vegetative cover through cropping permitted the winds to erode the land and make it unsuitable for use in agricultural operations.

The Sahel, on the southern edge of the Sahara Desert, is an ecologically fragile area. A persistent, 5-year drought has currently resulted in livestock mortality of 50 to 60 percent in Chad, Niger, and Senegal. Furthermore, it appears that desert conditions have been moving south at a rate of 1 1/2 to 50 kilometers per year. Figure 1-10 (on the following page) shows how trees are engulfed

by the shifting sands, as the desert continues to move southward in the Sahel.

It must be remembered, however, that conditions of this type represent a natural way of life for the area. The Sahel has had nine major, sustained droughts in the past 150 years. The problem is compounded because of population pressure. Given the carrying capacity of the land during dry periods, it can now be considered overstocked and overpopulated. Damage from drought, it might be added, is extremely difficult to determine since estimates should probably include the loss of animals which were never born and crops which were never sown.

Figure 1-9. REMOVAL OF VEGETATIVE COVER

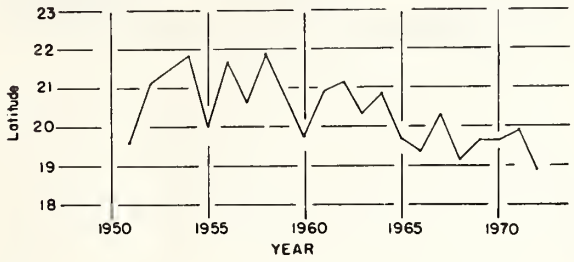
Source: After a Hundred Years. U.S. Department of Agriculture Yearbook. 1962.

Figure 1-10. MOVEMENT OF DESERT IN THE SAHEL

Source: War on Hunger. U.S. Agency for International Development. August 1974.

Figure 1-11 below shows some of the climatic conditions which have led to drought in the Sahel. The higher the latitude to which the rains penetrate, the greater the seasonal rainfall. This situation would also affect the vegetation in the area and thereby cause a spread of the desert conditions to the south.

Figure 1-11. NORTHWARD PENETRATION OF MONSOON RAINS IN THE SAHEL



Source: War on Hunger. U.S. Agency for International Development. August 1974.

4.23 Frost.--Frosts are prevalent almost everywhere except in tropical lowlands. They can occur at any time of the year in the mid-latitudes. Although crop loss may be localized, large areas on occasion can be affected. The Sao Paulo coffee region of Brazil, for example, has been hard hit by frosts on many occasions. Unlike cranberry bog farmers, for example, agriculturalists in most cases are unable to struggle successfully with this hazard. Perception in this case does not completely resolve the problem. Farmers will not tend to move because of a danger of frost. Accordingly, some form of government assistance or insurance seems desirable, but many nations are too short of funds to be able to afford this type of protection.

4.24 Fire.--There are two basic types of fire damage. The first occurs as an outcome of forest fires and the other results from agricultural practices involving controlled burning. Forest fires cause accelerated erosion and increase the danger of flooding in downstream areas. This is not always perceived or understood by the people involved. Controlled burning is associated with slash-burn agriculture or the burning of coarse dry savanna grass (see figure 1-12). Practices of this type exhaust soil fertility and are counterproductive, unless a long fallow period is involved. In some areas, such as parts of the Andes, steep slopes are burned over without any realization of, or concern over, the resulting damage; it is attributable, in part, to extreme land pressure. It is easy to burn dry grasses to get a clean field for plowing; but when a farmer does this, he may be destroying valuable organic materials. These protective coverings and soil improvers, given by nature, often cannot be purchased in a store.

Figure 1-12. BURNING TO REMOVE COARSE VEGETATION

Source: Soil. U.S. Department of Agriculture Yearbook. 1957.

4.25 Pollution.--Pollution is included in this section on hazards because of the health problems involved. Environmentalists maintain that the unrestrained use of fertilizers, herbicides, and insecticides has a bad effect on water

quality. Air pollution, as a result of agricultural land use, may also be involved. For example, grass burning on savannas, during a period of increasing temperature, can result in a level of pollution of the same order of magnitude as is found in many industrial cities.

The problem in relation to pollution has apparently been misunderstood by some leaders in developing countries. One such representative, speaking at the 1971 United Nations Conference on Asian Environments, stated that "The governments of developing countries...must not and will not allow themselves to be distracted from...economic development and growth by the illusory dream of an atmosphere free from smoke."[7] Others have commented on this subject in a similar manner. The confusion in this regard probably revolves around the definition of pollution and the degree to which it can be considered acceptable to a society. It is improbable that any responsible official in a developing nation would overlook air pollution which would materially affect crop yields, or water pollution which is a health hazard if used for drinking purposes or which might result in massive fish kills as have occurred in recent years in West Germany, the United States, Egypt, Kenya, Tanzania, and Algeria.

It is appropriate at this point to recognize that some pollution cannot be avoided. What must be determined on a technological basis is the danger level and the saturation point for a specific pollutant in a particular environment. Similar attempts should be made to ascertain danger levels which could be reached as a result of the cumulative effect of using many pollutants simultaneously. To make these determinations, it is also necessary to consider certain practical socio-economic and political matters which relate to the subject. Further, the people involved must set artistic and ethical goals for themselves in order to make the final decisions.

[7]As quoted in M. Gaghi Farver, et al. "The Pollution of Asia," *Environment* (October 1971), p. 10.

There has been considerable controversy in regard to the relationship between population and pollution.[8] Some observers have argued that the growth of the former results in an accompanying increase of the latter. Yet some of the most polluted areas are in developed countries with comparatively moderate population growth rates. One can, therefore, assume that the way in which the environment is perceived and managed is as significant a pollution determinant as the total number of people involved.

4.26 Erosion.--One of the major hazards presently facing populations throughout the world is erosion. The pattern is often the same. Soil maintenance is poor and the agents of erosion attack the surface and expose the subsoil. This may be a result of land pressure in poor countries or misdirected economic incentives which do not encourage a concern for this problem. The eroded material is funneled into streams or reservoirs, thus causing flooding. Figure 1-13 (on the opposite page) is a representation of a watershed with and without vegetative cover. The latter shows the resulting erosion. Figure 1-14 (on the opposite page) is a reservoir which has become clogged with silt from an eroding watershed, resulting in flooding.

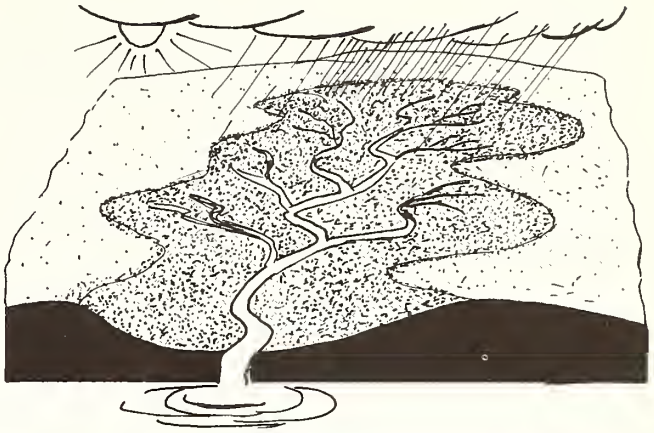
Urban areas could, therefore, suffer damage from erosion practices which originate in distant parts of the watershed. Reservoirs could also be adversely affected by the large amounts of sediment which enter into them. It is often difficult to combat the problem because individual farmers do not readily and quickly perceive, or wish to perceive, the cumulative and damaging effects of sheet and gully erosion taking place over a large area. In some places in China, for example, peasants may practice conservation on their plots in valley bottoms and yet adopt techniques on slopes which increase erosion from the surrounding hillsides.

[8]Frank W. Notestein. "Zero Population Growth," *Population Index* (Oct.-Dec. 1970), p. 455.
Amos Hawley. "Ecology and Population," *Science* (March 23, 1973), passim.

Figure 1-13. SCHEMATIC REPRESENTATION OF A WATERSHED

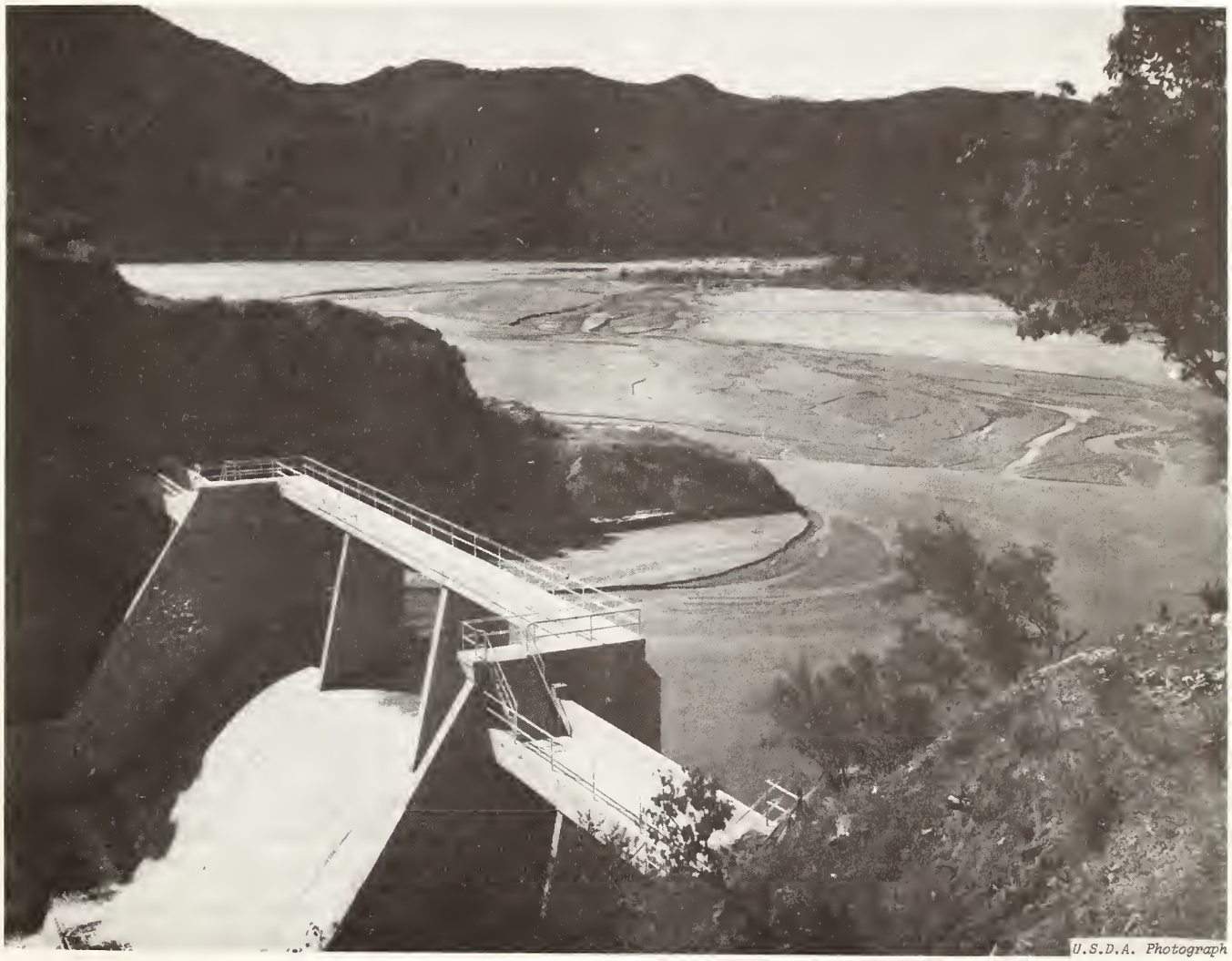
(With vegetative cover)

(Without cover, showing drainage and erosion)



Source: What is a Watershed? U.S. Department of Agriculture. PA-420. 1960.

Figure 1-14. CHOKED RESERVOIRS



U.S.D.A. Photograph

Source: Land. U.S. Department of Agriculture Yearbook. 1958.

4.3 Combatting hazards

Generally, reaction to hazards involves a recognition of the danger and an attempt to do something about it. As noted, the degree of response is closely tied to the frequency and magnitude of the hazard. In any event, disaster planning in most countries is generally the exception rather than the rule. Until recently, for example, places expecting flood damage in the United States could not be declared disaster areas and receive government assistance until the damage had actually taken place. In some cases, however, populations have no options open to them. Because of land pressure, they have no place else to go; and lack of capital often slows their efforts to deal with the hazard successfully. Nevertheless, cooperative efforts using volunteer labor have often been used effectively to improve local conditions.

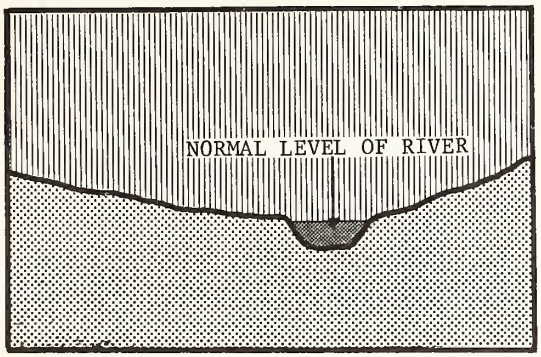
As a general rule, the forces of nature are so powerful that man cannot eliminate hazards completely. This does not imply that areas need necessarily be abandoned because of danger from a specific hazard; indeed, it would normally be politically, socially, and economically unreasonable to recommend such a course of action. A somewhat more reasonable proposal is to suggest that sensible use be made of land and that safeguards be taken to minimize rather than avoid damage. Preventative measures of this type are best taken by a well-informed population and government. There is a Chinese proverb which makes the following recommendation: if you plan for one year, plant rice; if you plan for 10 years, plant trees; if you plan for 100 years, educate men. Success, then, depends upon ecological understanding and upon such other variables as cultural attitudes and goals, availability of capital, level of technology, and administrative organization.

4.31 Flood protection.--A drainage basin is a simple physical unit which funnels water flow into its major stream. It is difficult to control the natural functioning of a watershed if it is politically fragmented; yet rivers are frequently used as administrative boundaries in practically all countries. Therefore, the solution must lie in some degree of cooperation among the political agencies involved.

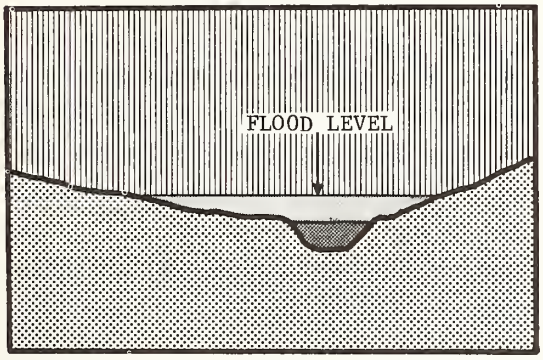
Flood control measures take various forms. For example, swelling water from the upper part of a basin and from tributaries can be reduced and delayed as it moves into the main channels by afforestation (planting of trees), reforestation, or by construction of small storage dams. Some developers prefer the construction of multipurpose dams along the main stream. Another scheme which has been attempted involves the deliberate flooding of the lowest parts of the river plain during periods of high water. These low areas are usually swampy, poorly drained, and are not intensively used. Perhaps the most common control measure taken is to build artificial levees on top of natural levees. (Natural levees are formed from sand and other material that the river dumps near its banks when it overflows.) The river slowly builds up its bed until it overflows both the natural and artificial levees during a period of high water; thus, artificial levees restrain flood waters only temporarily. Some engineers have recommended cutting new channels along the river course to facilitate the movement of flood waters through the lower part of the basin. All of these techniques have not, as yet, provided a completely satisfactory solution to the problem.

Little has been done to establish zoning regulations which would govern present and future land use on flood plains. For example, lower level areas could be reserved for grazing or cultivation and higher level areas for housing and industrial structures. (Refer to figure 1-15.) Furthermore, some efforts could also be made to minimize flood damage to buildings. This might involve less intensive use of the ground floor and a limitation on construction of windows so that they are restricted solely to the upper floors. Insurance protection and construction and improvement loans for high-risk areas usually do not put the financial burden of hazard damage upon the residents. Some governments agree to pay for flood damage, thus encouraging continued industrial, commercial, and residential occupancy of an area.

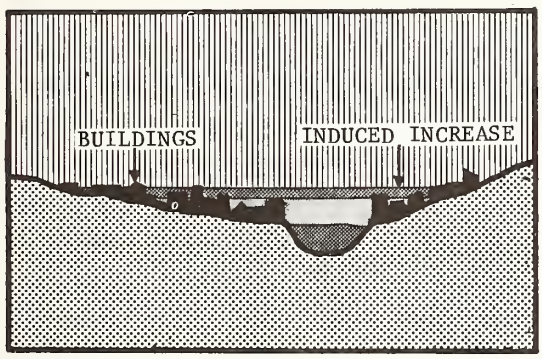
Figure 1-15. SELECTIVE USE OF A FLOOD PLAIN



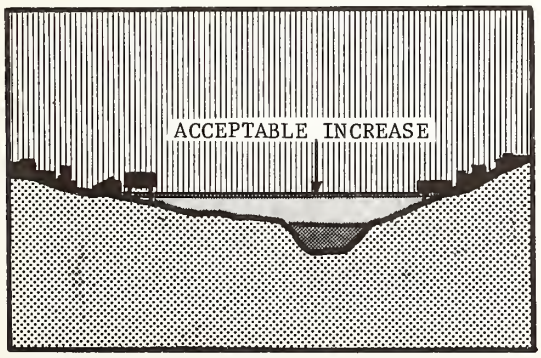
Normal level of river.



Without structures or other encroachments in the flood plain, this represents the level which the river has a 1-percent chance of reaching during any year.



With encroachments, the 1-percent chance flood would reach a higher level and greater width.



Selective use of flood plain to exclude structures in high energy zone, with suitable plan for structures and sites, permits the passage of floods and reduces the risk of flood damage.

Source: Water Spectrum. U.S. Department of the Army, Corps of Engineers. Summer 1971.

Probably, the greatest problem in regard to flood control involves the lack of hazard perception and the belief that a simple solution to the problem can be found. Thus, the tendency is for people and governments to gamble on higher levees or bigger dams. These prevent flooding for a period of time but they build a false sense of security for the people on the plain. As a result, the inhabitants are increasingly tempted to use the area more intensively and the population usually increases. Even when a record flood does occur after dams and levees are built, an understanding of the natural processes that are at work may still be lacking.

Storm damage along coasts is also difficult to combat technologically. In the Bangladesh disaster, for example, almost 3,200 kilometers of coastal embankments were constructed along the delta in order to cut down on damage from storms. These defenses were not able to contain the large volumes of water.

The economic and political aspects of coastal damage are also difficult to resolve. Even if the area were constantly subjected to damage, it still remains an important agricultural region which can support a large population. The people of the delta, in turn, have few alternative places to which they can migrate, even if they should choose to leave their homes.

4.32 Dams.--Most large modern dams are multipurpose in nature. They help prevent floods, produce electricity, provide water for irrigation, and sometimes facilitate river navigation. Such dams, however, have fundamental shortcomings. For example, two of the functions noted above are in disagreement. Flood control requires that a low head of water be retained in the reservoir, so that flood waters can be accommodated. On the other hand, the generation of electricity calls for the maintenance of a high enough head of water to run the generators and prevent shortages of electricity. To a degree, this latter situation (the need for water at a high level) can be eased by the construction of a series of dams. Nevertheless, such an alternative raises the cost of development substantially.

It has been noted that some controversy also has taken place over whether small storage dams should be built upstream or on tributaries, or whether a series of large, multipurpose dams should be constructed along the main stream. On occasion, both are built.

Within recent times, opponents of dams have pointed to the ecological imbalances which they create; these will be dealt with later in this chapter. In addition, dams have created other problems. If a river flows through an arid region, the lack of vegetative cover and the erosive force of the water may contribute to moving large amounts of silt (sand and fine dirt) and other deposits downstream. The reservoir acts as a receptacle into which all material carried by the river is finally dumped. The amount can be sizable. For example, sediment (silt and other deposits) carried by the Colorado River settles daily in Lake Mead, the reservoir of Hoover Dam in the United States; this sediment would fill about 80 freight trains, each of which contained 100 boxcars. The material does not leave the reservoir, and it would be too difficult and costly to remove it. Furthermore, the question arises as to where it could be taken and dumped even if it were dredged from the lake. Consequently, the reservoir will fill up eventually, creating a man-made waterfall. (See figure 1-14.) The process can be slowed, but not stopped, if small dams are built on tributaries. This situation is not unique. The Mangla Dam in Pakistan, built recently at a cost of $600 million, originally was supposed to have a life span of 100 years. Accelerated erosion in the watershed, however, has cut its life expectancy in half. Also, it is estimated that the Tarbela Dam in Pakistan, one of the largest in the world, will not only cost over $1 billion, but will last only 50 years.[9] Some experimentation has taken place in building dams with holes cut strategically in the face so as to permit floatation transport of sediment. This technique has met with some moderate success in Algeria, where it was tried recently.

[9]W. McQuade. "Global Earth-Shapers in Complex Competition," *Fortune*, Vol. LXXXI (April 1970), p. 87.

Other consequences of siltation are to be found on both sides of the reservoir. On the one hand, large amounts of silt and other material are often deposited upstream from the reservoir, tending to impede river flow and possibly causing some flooding. Downstream, the lack of sediment in the water below the dam permits the river to erode its delta and to scour its bed and banks. One result is that the river then lies well below its original level, thus having a bad effect on downstream irrigation systems which depend on water taken directly from the main stream; expensive pumping systems must then be installed.

All things considered, it should be pointed out that no completely effective form of flood control has yet been devised. Also, it might be argued that the economic life of a dam may have ended by the time the reservoir becomes filled. Finally, siltation of reservoirs in humid regions is simply not as great a problem as it is in arid areas. Of course, water demand may be less in humid regions than in arid areas.

4.33 Droughts and weather modification.-- Some 2,000 years ago, the Emperor Xerxes of Persia ordered that the Hellespont water passage be lashed 100 times by his charioteers because a storm had destroyed his pontoon bridge. Possibly man's active attempt to master the weather stems from even earlier periods. Yet it is only within recent times that man has achieved some degree of success through his efforts in cloud seeding. Although statistical evidence strongly suggests that this technique has been fairly effective, it is nevertheless true that only clouds with a potential for precipitation can be seeded with any expectation of success.

Even so, the case for seeding is a very strong one. Experimentation is continuing; the Soviets maintain that some favorable results have been obtained in their attempts to develop seeding techniques to avert hailstorms.

Despite the foregoing, no method has been devised that can effectively fight sustained drought in semi-arid areas. The solution, if it can be called that, must be expressed in negative terms. Simply stated, such places must not be overused.

The green, wet years should not be considered indicative of the area's average productive capabilities. Such a recommendation is easier to state than enforce, however. It involves education of the agricultural population and regulation and control of land use. The solution must also address itself to the question of land pressure and find some way to counter the gambling instinct of many farmers and stockmen. The remedy, then, involves political, social, and economic considerations; the technological aspects apparently hold little prospect for help in the immediate future. This also holds true for salt-water conversion if interior rather than coastal areas are involved; costs are normally too high to pump fresh water inland to potential irrigable sites.

4.34 Erosion control.--Erosion of the land is difficult to control. The physical measures which should be taken often can be determined readily, although the damage may have reached a point at which the erosion can only be held in check or the rate slowed down. Complications arise mainly as a result of the non-physical or social factors. For example, the conditions of farming may be such that they promote misuse of the land. This may be a result of disinterested, absentee ownership; or it may be the result of overpopulation, land hunger, or unfavorable tenancy arrangements. Erosion, then, often must be dealt with on a political, economic, and social basis.

The usual conservation measures taken in relation to erosion control include crop rotation, strip cropping, contouring, stubble mulching, terracing, and replacement of the vegetative cover. Growth of gullies (ditches created by running water) can be stopped by construction of small check dams which trap eroded material.

One of the first steps in soil conservation involves the development of a land classification scheme which would, among other things, categorize agricultural land according to its ability to resist erosion. This, in turn, would facilitate instruction to farmers on proper management practices, and it would provide useful guidelines for soil conservation agencies.

5. ECOLOGIC BALANCE

Ecology is the study of the interaction of living organisms among themselves and with their environment. It is a science in which there often is limited understanding of the way in which an ecological system, or ecosystem, works. The end result of an ecological change, therefore, may be unexpected or at least not always readily apparent. For example, the introduction of large amounts of carbon dioxide into the atmosphere may change average world temperatures; it is not yet clear what direction the reaction will take nor what the end result may be. There are many variations of this theme. The introduction of rabbits into Australia is a classic example. The rabbits had no natural enemy to attack them, and their subsequent population explosion destroyed the grass cover available for sheep. Similar results occurred when imbalances were created in bird-insect ratios in China and coyote-prairie dog ratios in the United States. In Thailand and Borneo recently, insecticides used in mosquito sprays were picked up by cockroaches and passed on by house lizards to cats. An increase in cat mortality resulted in an explosion of village rat populations. One can, of course, overstate the case. About 100 years ago, someone equated the fate of the British Empire with the number of unmarried ladies and cats in England by some unreliable reasoning. It does appear, however, that tampering of life chains often have some far-reaching and compounding effects.

It seems that certain ecosystems are more susceptible to damage and change than are others. This is particularly true of polar regions, deserts, marshlands, and tropical rainforests. For example, the conversion of tropical rainforests to semi-permanent savanna, by burning, quickly results in soil deterioration, both in terms of structure as well as nutritive value. Irrigated desert soils can become salty within a comparatively brief period of time. Careless construction of housing or roads on top of frozen ground in polar areas has resulted in a very damaging form of erosion. The ability of these areas to recover from such change may be poor or slow at best.

5.1 Problems of ecological change

People often take opposite positions in regard to man's role in changing ecological balances. On the one hand, persons who believe in careful preservation and protection of natural resources are opposed to almost all change. Their view is that, without a clear understanding of results, ecological change could be harmful. Since the final outcome of environmental changes cannot be determined with certainty, their feeling is that things should be left as they are. On the other hand, some people see no basic dangers involved in putting technology to work to develop and supposedly improve man's habitat. For example, certain Brazilians maintain that it is not desirable to preserve the Amazonian environment in its natural state, given the national need to improve the level of living.[10] Some observers in developed nations have been quick and probably right to criticize such attitudes; nevertheless, problems caused by an energy shortage seem to have lessened the concern of some people in those same countries over pollution levels and other forms of environmental mismanagement.

Another example which indicates the lack of a clear understanding of the implications of technological change involves DDT (a chemical that kills insects). Its introduction has undoubtedly lowered mortality rates in malarial infested areas throughout the world. To mention a frequently cited case, massive spraying during late 1946 and early 1947 in Sri Lanka (Ceylon) cut the death rate by more than 30 percent. Accordingly, many medical authorities view the use of DDT as beneficial, on the whole, since it has the immediate effect of saving lives. Health experts are not ecological experts, however. Ecological damage from DDT may or may not be as great as some alarmists claim. Nevertheless, it would appear as though an impartial assessment of benefits and costs is best undertaken by a team of people representing a variety of interests in the physical and social sciences, before a final determination is made. This highlights the inter-disciplinary nature of the science of ecology; no indivdual or single science can lay claim to complete expertise. To return to the case of DDT and Sri Lanka, the spraying program was successful and therefore was phased out by 1966. Two years later, malaria had again reached serious proportions and the spraying program was resumed in 1969. The Assam Province of India has undergone a similar experience. How long and to what degree can DDT continue to be used? It would appear to be misguided judgment to rely on medical advice solely in determining whether these DDT programs should be continued.

[10]William Denevan. "Development and the Imminent Demise of the Amazon Rain Forest," *The Professional Geographer* (May 1973), p. 133.

5.2 Environmental mismanagement

A lack of understanding of the components of change in an environment will finally result in ecological damage by some of the new practices. Several examples follow.

5.21 Increase of salinization.--The first case is that of salinization (large amounts of salt in the soil). Figures 1-16 and 1-17 illustrate how growth of crops can be affected by soil which has an excess of salt.

Irrigation schemes in arid and semi-arid areas often have been undertaken without provision for proper drainage of water off the land. As a result, the water table may rise and the dry air may pull moisture up through the soil. Evaporation then takes place and the salts brought up by the water are deposited at varying levels in the soil horizon. In many cases, the salts appear at or near the surface. Very large land areas may be affected in this way. Irrigation of the Indus River basin in Pakistan, for example, has caused damage to huge land areas. By the early 1960's, the rate of salinization in this area was averaging over 24,000 hectares a year. Ancient hydraulic civilizations were affected in the same way. Thus, a major part of the irrigated Tigris-Euphrates valley may have been abandoned because of soil salinization, rather than destruction of the water distribution system by invading nomads.

Figure 1-16. SALINE SOIL
(Cotton on saline soil has an irregular stand and growth)

Source: After a Hundred Years. U.S. Department of Agriculture Yearbook. 1962.

Figure 1-17. NONSALINE SOIL
(Cotton on nonsaline soil has a uniform stand and growth)

Source: After a Hundred Years. U.S. Department of Agriculture Yearbook. 1962.

The solution to salinization is a costly one. A drainage system must be installed and large amounts of water used to flush the salts away. Usually, this type of reclamation is not economically feasible.

5.22 Removal of vegetative cover.--The second case involves a subject which has been touched upon--man's removal of vegetative cover (see figure 1-9). It has been stressed that the implications and dangers have not always been understood. For example, children in the United States are told stories of the great physical skill of a mythical hero, a forester named Paul Bunyan. He is closely associated with the period when the large forests of the northern Mid-West were cut to excess. A good deal of the accelerated erosion, downstream flooding, and damage along the Mississippi River valley was a direct result of the destruction of this resource. It would appear that Paul Bunyan could be portrayed as an ecological villain just as easily as he can be portrayed as a hero.

There are other examples of mismanagement of forest cover. The small islands of the Grenadines, in the Caribbean, have been converted from subtropical forests to desert in less than 150 years. In Madagascar, only 70,000 square kilometers remain of a forest reserve that originally covered 600,000 square kilometers; the area now has a poorer quality soil and is mainly scrub savanna. During the Middle Ages, the Charbonniere Forest between Belgium and Holland was so thick it served as an effective divide between the two peoples; no trace of it remains today. At the present rate of cutting, the forests of eastern Paraguay should last only 10 years more. Some observers suggest that this also could happen to the Amazon rainforest.[11] A forest is a renewable resource only if people see the value of sustained yields and erosion control; if they do not, those responsible for overcutting are simply opportunists who, according to the Brazilian writer, Holanda, wish to pluck the fruit without planting the tree.

[11]William Denevan. "Development and the Imminent Demise of the Amazon Rain Forest," *The Professional Geographer* (May 1973), passim.

5.23 Misplacing of dams.--The third example involves dams. Some of the difficulties in regard to their construction and operation have been mentioned earlier. Other ecological problems are also worth noting. Probably one of the best publicized cases has been that of the High Aswan Dam in Egypt. It has raised water tables, increased salinization, and accelerated the downstream scouring of the Nile River bed and delta. Siltation and water evaporation off Lake Nasser are also problems. In addition, the absence of silt and the even flow of water at the delta has resulted in the breaking of an aquatic life chain and the decline of the sardine fishing industry in the eastern Mediterranean. The availability of year-round irrigation water has also increased the spread of the disease bilharzia. This has also happened in the irrigated zone watered by the Volta Dam in Ghana. One might also add that it is possible that the heavy weight of water in a very large reservoir may cause minor earthquakes. Lake Kariba, a reservoir located along the Zambesi River between Zambia and Rhodesia, can be mentioned in this regard.

5.24 Elimination of marshlands.--Filling in of marshlands constitutes another example of poor perception and environmental mismanagement. In many cases, such areas serve as water storage basins and spawning grounds for large numbers of fish. These marshes also provide a home for local birds and a haven for those moving along flyways. Marshlands often can provide more protein per hectare than can most types of agricultural land. Traditionally, however, poorly drained swamps and tidal flats have been perceived solely as nuisances to urban life or as potential sites for farms.

5.3 Social factor

Often the degree to which an area can recover from ecological damage is as much a function of social organization as it is of physical conditions. For example, there was great concern over the ability and time needed for nature to repair the damage created in the Dust Bowl in the United States in the decade of the 1930's. Since popula-

tion pressure and land hunger presented no real problems, improved agricultural techniques could be employed in the area. Consequently, the region experienced a faster rate of recovery than had been anticipated. On the other hand, it does not appear that the Sahel region has the same ability to recover, given the overpopulation now prevalent in that region. The Sahel solution, therefore, must be (at least in part) a social one. In other words, environmental management has to focus on man as well as on nature.

6. SUMMARY

If modern man is not at the complete mercy of the environment, neither does he appear to be entirely the master of it. His knowledge of ecological processes is incomplete and his perception of the environment may be in error. An examination of the components of the physical landscape supports the reasoning that man must operate within nature's framework or endure the results. Within the constraints imposed by nature, however, he can have certain choices of action open to him. In this sense, his ability to control or improve his environment depends as much on social organization as it does on technological skill. Thus, any attempt to help a damaged habitat (such as the Sahel) to recover depends, in very large measure, on man's administrative capabilities and on the degree of population pressure and land shortage in the area. These considerations are essentially economic, political, and social in nature.

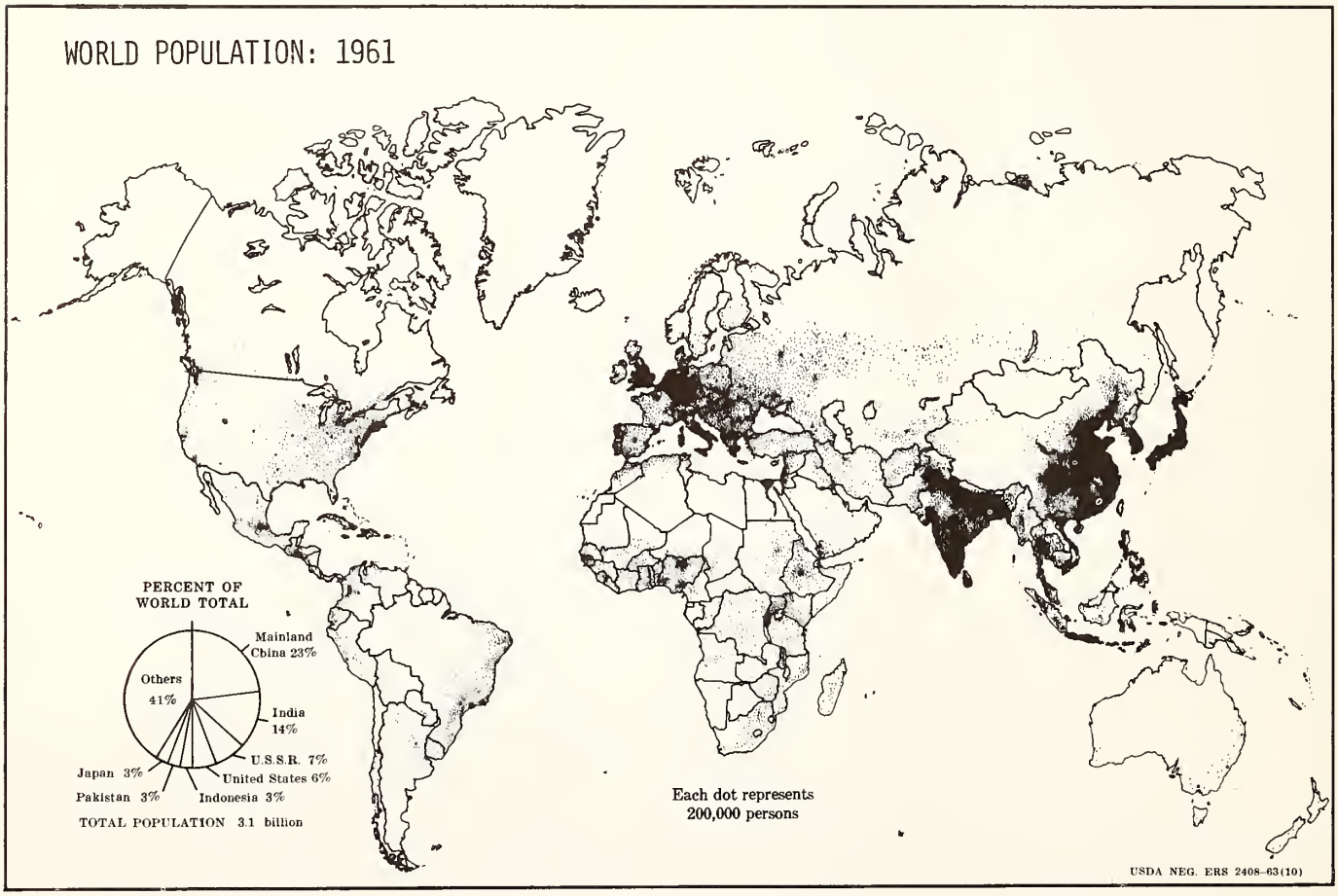
Chapter 2. POPULATION FACTOR

1. INTRODUCTION

The human population of the world will double its current number in about 35 years and nearly triple in 50 years if the present rates of growth continue. As a result of different growth rates, it is quite possible that by the year 2000, 8 out of every 10 persons will be living in what are now considered to be developing countries. (Refer to figures 2-1 and 2-2. Note that figure 2-1 is based on 1961 data and figure 2-2 starts with 1970.)

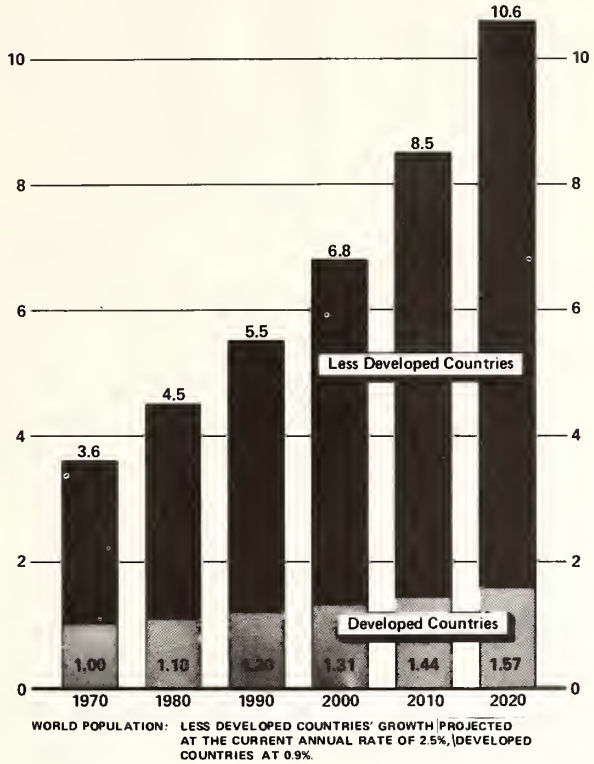
Such sizable growth raises qualitative and quantitative questions regarding levels of living (see figure 2-3) and the world's ability to increase its production of food to feed adequately about 7 billion people. This present chapter is concerned with population distribution, migration, growth, settlement, and employment. Chapter 3 discusses agricultural matters; and chapter 4 deals with the question of how to increase world food production to meet population needs.

Figure 2-1. WORLD POPULATION



Source: A Graphic Summary of World Agriculture. U.S. Department of Agriculture. 1964.

Figure 2-2. POPULATION EXPLOSION
(Billions of people)



Source: War on Hunger. U.S. Agency for International Development. December 1974.

2. DISTRIBUTION

The distribution of the world's human population is uneven. The major areas of population concentration cover only about one quarter of the land surface. Land use and economic activity are fairly intensive in these places. By contrast, the remaining land surface is sparsely settled and little used, and includes deserts, polar regions, tropical rainforests, most highlands, and swamps; these types of areas have successfully resisted advances of large numbers of people from earliest times to the present.

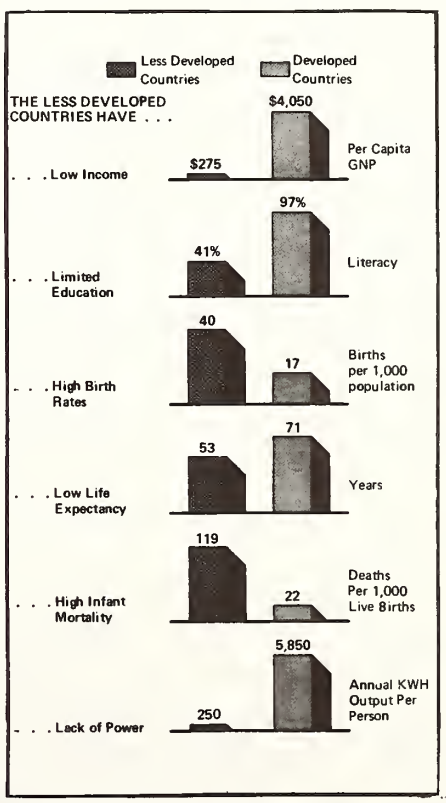
The distribution of people can be grouped in several different ways. About 90 percent of the world's population live within 1,000 kilometers of the sea, on plains, and below 2,000 meters in elevation. Almost half the world's population is located in four countries--India, the People's Republic of China, the U.S.S.R., and the United States. Even within these areas of concentration, however, the distribution is still very uneven. The areas of more intensive land use and larger populations are known as the "ecumene"; the empty regions are referred to as the "nonecumene."

Population masses, or their lack, are the result of both physical and non-physical conditions. In most cases, it would be in error to explain distributions solely in terms of one or the other of these factors. They will be discussed separately; however, they often operate together in creating conditions which are favorable or unfavorable to settlement.

2.1 Physical factors

Plains provide man with a somewhat more favorable environment than do the other types of landforms (hills, mountains, plateaus). Plains permit easy settlement and movement; one does not find the kinds of obstacles that are common to mountainous areas and plateaus. However, not all plains necessarily attract people. The Amazon Basin, the

Figure 2-3. THE DEVELOPMENT GAP



Source: War on Hunger. U.S. Agency for International Development. December 1974.

Great Plains in the United States, and the West Siberian Lowlands are not densely settled.

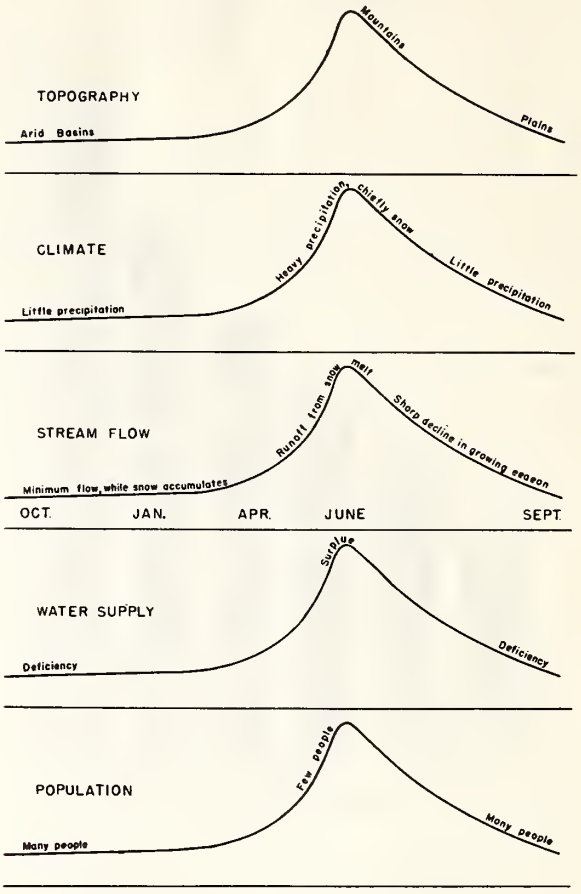
Consider some of the effects that rugged terrain forces on the movement of people and goods. To travel from the North Rim to the South Rim of the Grand Canyon in the United States, for example, is a fairly short distance as a plane flies. It is, however, a long and circuitous route if one has to travel along the plateau surface. To mention another example, goods moved from the People's Republic of China to Nepal have often gone by ship to India and then to Kathmandu, Nepal. The trip is longer, but the route is easier to travel. Similarly, a trip from Lima to Iquitos in Peru normally involves a seagoing voyage through the Panama Canal and a boat ride up the Amazon River to avoid the barrier created by the Andes Mountains.

The mixing of people, goods, and ideas is therefore easier on the plains, and inbreeding due to isolation is less apt to occur. Coastal plains are particularly favorable in this regard. Another factor, also quite important, is that soils are generally deeper on plains. Thus, if available water is adequate enough, this type of landform can, all things being equal, develop readily and easily as an agricultural region.

Figure 2-4 shows a fairly typical pattern of population distribution around a mountainous area. Water can be obtained on the plains along the base of the mountain chain; accordingly, populations are located there, despite moisture deficiency due to an arid climate. Note that few people live in the area with steep slopes despite the precipitation and availability of water.

In spite of the difficulties of living in mountainous terrain, people do not completely avoid them for habitation. The Andes Mountains in South America, for example, have large concentrations of people living at high elevations. These population clusters are mainly located in natural basins in mountainous areas and the peoples in them have tended traditionally to remain somewhat isolated from each other.

Figure 2-4. POPULATION DISTRIBUTION AROUND A MOUNTAINOUS AREA



Source: The Physical and Economic Foundation of Natural Resources--III. Interior and Insular Affairs Committee. U.S. House of Representatives. 1952.

Within recent times, scientific and technological advances have permitted man to live in undesirable places. Swamps have been drained, desert areas have been irrigated, and mountainous areas have been made more accessible through road construction and the use of aircraft. There are now over 1 million persons living north of the Arctic Circle in the U.S.S.R., and roughly the same number of inhabitants in Amazonia in Brazil. However, it often proves difficult to recruit volunteer settlers for some of these areas.

Although there has been recent settlement in parts of the nonecumene, current world population distribution has not changed substantially in modern times. It seems improbable that the present large, empty areas of the world will be in a position to challenge the superiority of the ecumene in the near future.

2.2 Cultural factors

Non-physical factors (or cultural factors, as the geographer would designate them) account significantly for the whereabouts of certain populations. Specifically, one can focus on economic, social, and political factors which appear to influence settlement patterns.

2.21 Economic considerations.--Economic considerations can exert a very strong influence in attracting and building concentrations of populations. People tend to converge to those segments of the ecumene which are reported to offer the best opportunities for obtaining a livelihood. For example, 42 percent of the population of Zambia is located along a belt 40 kilometers wide on both sides of the main rail line that connects the major mining centers of the country. By contrast, gainful and productive employment usually is more difficult to find in nonecumene areas. Occasionally, "boom towns," such as mining centers, spring up in undesirable areas; but they seldom generate other major economic activities and residents quickly depart once the resource is gone. This would account for abandoned mining towns in Mexico, Bolivia, or in the western United States, for example.

In some cases, people living on poor land often have higher levels of living than those residing in regions with better and more abundant resources. The answer, at least in part, rests on social organization, incentives, and goals. In addition, people view certain areas favorably because their social roots are there. Sizable population concentrations are often found in poor areas, despite the fact that economic opportunities are limited. The reluctance, in the past, of the Indonesians to move into Sumatra or of the Ethiopians to move into their lowlands or of the Japanese to move to northern Hokkaido can be cited as examples.

2.22 Political considerations.--Population distribution is affected by political considerations as well. Historically, governments have attempted to move people by persuasion or even by resorting to force, with varying degrees of success. The impact of political policy shows wide differences. Ecuador, in spite of official pleading, has not been able to move many colonists into its eastern area, whereas migration between India and Pakistan at the time of partition was partially forced and was quite sizable. By contrast, fairly large internal movements of people into the eastern part of Paraguay have taken place without much government urging, whereas the People's Republic of China has not been able to encourage large numbers of Chinese to move into Tsinghai or Sinkiang.

2.23 Combination of factors.--Very often, combinations of factors account for distribution patterns. For example, the economic cost required to connect the ecumene with those isolated areas which seem to have development potential is often so high as to make it impractical; it is also difficult to induce settlers to move into such places.

It is sometimes argued that the economic and social costs incurred in frontier colonization schemes could more profitably be spent in the ecumene in the first place. It is this argument which often prevails in deciding whether to increase agricultural production by means of higher yields in the ecumene or to expand cultivated areas into frontier zones.

3. MIGRATION

There are two types of internal migration which may currently have an impact on rural areas. The first involves urbanization and the other is the movement to frontier zones. In terms of magnitude, the former is much larger than the latter, although there are often great variations between countries.

3.1 Natural growth

As a result of natural growth, as well as migration, about 40 percent of the world's population now live in urban places. By contrast, the absolute growth of frontiers is not nearly so

great; additional occupancy of the nonecumene has been comparatively modest. This trend is not new. For example, examination of the history of population distribution in the United States shows a definite movement into the western frontier, but it also reveals a much larger absolute growth in the eastern half of the country since colonial times. Similarly, the Brazilian government has currently focused on its frontier. Its capital city has been shifted and a Trans-Amazonian road network is under construction. Yet, Brazilia is located within the ecumene. Furthermore, its distance from the coast is comparable to that of Chicago from Megalopolis (which is the heavy concentration of cities on the northeastern coast of the United States). Undoubtedly, the new Amazon roads will attract many settlers, but there is little evidence to indicate that such a migration stream will approach the rural to urban movement in terms of magnitude.

3.2 Urban migration

It has been suggested that urban migration streams are not easily controlled or manipulated.[12] The unsuccessful but often expressed desire of some governments to limit the size of certain cities seems to support this view. It is difficult to keep the people "down on the farm," given the perceptions they may have of city life and opportunities. Some nations have required work permits, such as the Dutch have done in their Randstadt (Amsterdam-Rotterdam-The Hague) area. Others, such as the Soviets, have at times restricted housing starts. South Korea imposed a citizenship tax on households in Seoul in order to slow down the rate of urbanization. The Cuban regime has managed to decrease the rate of growth of Havana, but this has been done by promoting industrialization in other selected urban centers. The Tanzanian government has recommended that new industries, wherever possible, be located outside its capital of Dar es Salaam. The list of countries which have attempted various measures to turn or slow urban growth is a long one, but few can point to much success.

Rural people in many countries, moreover, do not seem to object to living in urban slums. This is apparently because their satisfactions still exceed their expectations. Despite very bad housing and sanitation conditions, residents in those areas often find that medical and educational services, particularly for the children, are more readily available in urban rather than rural areas. Also, these people often do not pay rent for their living quarters, nor do they have to work part time tilling the soil of the farm owner on whose land they reside. Slum dwellers also seem to find that more social and recreation facilities are available to them in cities. Accordingly, there is less political unrest in expanding urban centers than had been anticipated.[13] It seems reasonable to assume, then, that urban growth will continue.

Many governments view the effects of urbanization with alarm. Pressures on housing, transportation, and social services continue to increase substantially; slums grow and crowding seems to become a way of life. Efforts to create more urban jobs are sometimes considered counterproductive, since they also tend to increase the flow of migrants into the city. As a result, there is a tendency to think that the only way to slow down the urban movement is to make rural life more attractive. This, in turn, involves a choice of alternatives--to develop competitive attractions in the ecumene or in the frontier lands of the world. It has been pointed out that frontiers have not usually drawn large numbers of migrants, in spite of the efforts by many governments to draw people into them. This is not to suggest that a completely unchanging situation exists. Some centers in such places as the Montaña, along

[12] Harley L. Browning. "Urbanization and Modernization in Latin America: The Demographic Perspective," in *The Urban Explosion in Latin America*, ed. by Glenn H. Beyer (New York: Cornell University Press, 1967), p. 74.

[13] Wayne A. Cornelius. "Urbanization as an Agent in Latin America Political Instability," *American Political Science Review* (September 1969), passim.

the eastern flank of the Andes, have grown modestly. Indeed, some observers maintain that large population shifts and a new equilibrium in distribution are possible in the future. For example, a fairly comprehensive United States government report on the world food supply suggested that population pressure in Asia might induce migrations to the Americas and to Africa which would be comparable to those of the 19th Century.[14] Given the present obstacles to international migration, this possibility seems doubtful at best. Nevertheless, future events are hard to predict.

3.3 Rural population growth

Economic development of agricultural areas in the ecumene is, in part, offset by rapid rural population growth. It may be true that the perceived attractions of the city and poor conditions in the countryside seem to reinforce each other and accelerate urban migration. Nevertheless, rural areas still suffer from the effects of overpopulation. Furthermore, the problems of improving the economic base in these areas are great indeed. After major government efforts, the Northeast in Brazil, Appalachia in the United States, and the Mezzogiorno in Italy remain basically poor rural regions.

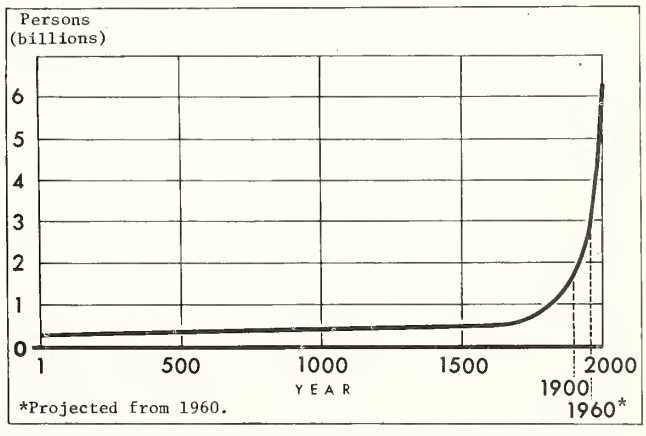
4. POPULATION GROWTH

There is a considerable amount of literature on the current population explosion, and the reader is directed to other documents for detailed coverage of the subject. The objective of the following section is merely to highlight some of the more important characteristics and consequences of this growth.

To begin with, the present population explosion is not the first one to occur; there were two others. One took place at the time of the Agricultural Revolution, some 10,000 years ago. Another explosion occurred during the Industrial Revolution which started in the 18th Century. It is particularly appropriate to point this out, since this chapter is concerned with the relationship of people and resources. Although much smaller numbers of people were involved in these earlier expansions, the available scientific and technological skills of those times limited the degree to which the resource base could be utilized. Population pressure was eased in both cases by an expansion into empty but generally accessible and favorable areas. Significantly, it does not appear as though current problems can be solved in this manner.

The current rates of growth cannot be sustained indefinitely, regardless of technological achievement. Figure 2-5 illustrates estimated future population increases. Increases after 1970 are based on the assumption that growth rates will not change. The chart does not indicate trends beyond the year 2000, but an observer might assume that future population growth would continue indefinitely.

Figure 2-5. TWENTY CENTURIES OF WORLD POPULATION GROWTH



Source: Man, Land, and Food. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 11. November 1963.

Straight-line projections which assume unchanging trends can be misleading. For example, if a man weighing 100 kilos dieted and consistently lost 1 kilo per month, he would lose about 12 kilos per year and would disappear completely in roughly 8 1/2 years. To illustrate this point even further,

[14] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, pp. 83-84.

consider the statement made by William Godwin, a contemporary and an opponent of Malthus. Mr. Godwin suggested that the day would come when one flower pot could supply enough food for one person for a year. If current growth rates are projected into the future, it becomes apparent that the world would ultimately run out of space for the flower pots. Before that day would come, of course, mortality would start to rise. The alternative to sustained high growth rates and poverty would appear to involve some form of population control as well as some attempts at economic development. As a Director General of the FAO has indicated, the developing nations must start to "plan their population growth instead of letting it happen."[15]

Attitudes regarding population control are hard to change. One author cites a middle-aged peasant farmer who had benefited from the Green Revolution as saying, "It's too bad...(the Rice Institute) didn't make miracle rice a few years earlier. If they had, my wife and I could have had more children."[16] In other words, population control implies a change in people's motivations, goals, and incentives. It does not appear as if these can be changed easily or quickly.

Large-scale urbanization does not hide the fact that rural fertility has remained high. Although many people feel that urban growth is undesirable, some observers consider such migration as favorable, since it seems to relieve rural land pressure.[17] Yet, high rural growth rates will offset such gain unless some major effort at population control is adopted in the countryside.

The size of the agricultural labor force would not be affected by a sudden drop in birth rates for a period of about 15 years, since it would take that long for the smaller sized cohorts to become part of the economically active population. Yet, total population growth over the next decade and a half will be sizable. Accordingly, two goals must be pursued simultaneously--population control and improved agricultural production. A solution to one problem should be accompanied by renewed efforts in the other in order to help correct the population-food imbalance.

Finally, it has been noted that population growth is often tied closely to pollution and ecological mismanagement. In many developing countries, for example, increasing levels of overpopulation and land hunger are a cause of accelerated soil erosion. It is sometimes suggested that such problems are not a result of population pressure, but rather of social maladjustment and lack of environmental controls. Persons who agree with this reasoning point to the theoretical case of a country which could presumably decrease pollution levels and increase population at the same time. On the other hand, it is argued that one can imagine the reverse possibility--increasing pollution levels and decreasing population.

The concern, therefore, is not so much a matter of population size, but rather of what the people are doing. What are their economic, social, and political goals and how are these objectives implemented?[18] Having made this point, the fact still remains that ecological mismanagement is commonly associated with a growing population and an increase in levels of living.

In developed nations, modest population increases are accompanied by even greater demands upon the resource base, often without much regard for ecological effects. On the other hand, in many emerging nations, land pressure due to overpopulation is made more acute by the introduction of more mouths to feed. It then becomes simply a textbook exercise as to whether a population could theoretically grow in size without harming its environment.

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[15] Food and Agriculture Organization. *The State of Food and Agriculture, 1971* (Rome: 1971), p. 217.

[16] R.E. Huke. "San Bartolemé and the Green Revolution," *Economic Geography* (January 1974), p. 59.

[17] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, p. 86.

[18] Frank W. Notestein. "Zero Population Growth," *Population Index* (Oct.-Dec. 1970), p. 446.

5. SETTLEMENT PATTERNS

Spatial patterns of settlement do not always clearly indicate the location of the boundary line between urban and rural areas. In some cases, a city wall or a row of houses may serve such a function. More commonly the urban-rural division is a complex one, and the boundary is very difficult to define. Administrative lines often are used, but they are not functional in terms of land use since they commonly do not separate the rural from the urban. Therefore, it is important to define the terms and explain the reasons for the designation of both types of areas.

5.1 Types of settlement

There are two different types of settlement--dispersed (or scattered) and clustered (or agglomerated). It is often assumed that the dispersed population describes rural areas and clustered population describes urban places; however, this is not necessarily the case. For example, a dispersed, urban-oriented population can sometimes be found in the area beyond the suburbs of a large city. These people want to live in low density places, but they may work in the city and demand various kinds of urban services. Such a population is non-agricultural, although the people live in an area which many would designate as rural.

At the opposite end of the scale are to be found small agglomerations, consisting of farm houses. The farmers in these houses live close to each other, but they cultivate plots of land which may be located at some distance from the nucleus. No urban services are associated with this cluster. Such a place, sometimes called an agro-village, is rural both in character and function.

5.2 Urban-rural definition

Each nation decides for itself what it considers to be urban area; the remaining area is then defined as rural. Little effort is made to classify the latter in homogeneous groups. This is unfortunate, since rural areas often differ from each other in terms of the degree to which they are either rural or urban. For example, an area with a rural non-farm population or with a concentration of vegetable farms clustered around a large city, is different in character from range land or wheat belts which are far removed from large urban centers.

Generally, urban places are designated in five different ways. First, clustered settlements can be defined by population size, all places above some arbitrary limit being included in the urban category. Thus, in Jordan all places above 10,000 population might be considered as urban; in Zaire, the cut-off might be set at 2,000. In some cases any cluster, regardless of size, may be counted as urban. Because of the great variation in size limits and the subsequent difficulty in making comparable studies of urban or rural statistics, the United Nations recommends that all places of 20,000 or more be classified as urban.

Second, areas of high density may qualify as urban. In the United States, for example, suburbs of large cities are considered urban if they have a density of 400 or more per square kilometer.

Third, a place is urban if it has some legal basis for existence, or if it is an administrative center of some sort. Similarly, in some countries a place is urban if it is controlled by some designated type of political entity.

Fourth, a place is urban if some sort of urban function is involved. In Central America this might refer to the existence of piped water or the availability of electricity in a certain proportion of the housing units. In other nations, it might refer to the availability of public transportation, the degree of fire and police protection, the types and quality of the educational facilities, or the percentage of non-agricultural workers.

A fifth means of designating places as urban is to use criteria which are unique to the country making the determination. For example, before the advent of the Castro regime in Cuba, towns with streets that had names were considered urban. In Ethiopia, it has been suggested that one criterion

for an urban place should be that the center have a tavern or similar type of establishment in which alcoholic beverages are sold. In some countries, an arbitrarily chosen number of the largest cities are declared urban. Others combine a number of the foregoing criteria to make their designations.

Although the definitions of urban places vary greatly, they often make sense if considered within the cultural and economic framework of the country involved. There are difficulties, however, in making comparisons between nations. What is urban in Thailand and what is urban in the Sudan might differ so substantially that any attempt to compare the urban populations of each could be very misleading. Accordingly, observers should use these data very carefully.

5.3 Urban places and their tributary areas

Early Egyptian hieroglyphics designated an urban place by a symbol composed of two crossed lines bounded by a circle.[19] The two lines represented a crossroads and the circle presumably portrayed a wall or some sort of town (or village) boundary. Another interpretation suggests that the point where the two lines met was the site of the urban place and that the circle enclosed the tributary area. This also suggests that a close relationship must have existed between the village and the open country.

A village provides a marketplace for farmers and is, in turn, a center where goods and services can be obtained. These central places are themselves linked in an ordered system to larger urban places and then to cities. Each center which is higher in rank order has a larger tributary area. The number of commercial establishments or the size of a settlement is normally closely linked to the population size, transportation system, and purchasing power of the market area beyond the settlement; additionally, they are closely linked to the relationship of the center to the other clusters in the region.

Urban places perform good and valid functions for the surrounding areas. The latter areas, in turn, may be rural in character, but their activities are very much conditioned by their closeness to an urban center. To a degree, this accounts for the concept of "city region." Land use and settlement in such an area is best explained in terms of the close relationship between town and countryside. A good example of this can be seen in Megalopolis, the urban complex in the northeastern part of the United States. This is probably the largest urban concentration in the world, yet it contains a variety of settlements, new and old, of differing sizes and functions. Large segments of the region have very low densities and many are strictly agricultural in character.[20] They contain concentrations of vegetable farms, nurseries, green houses, dairy farms, and poultry farms. However, all activities in the region, agricultural and non-agricultural, are significantly related to the existence of large, nearby metropolitan agglomerations. Similarly, the United States designation of "standard metropolitan statistical areas" follows the same reasoning to a degree--central cities are combined with tributary areas to form an integrated urban type of unit.

The close relationship of an urban place and its tributary area is not unique to the United States. The existence of vegetable farms and green belts around many urban places in the world is evidence that agricultural land-use patterns are based on distance to the city and the accessibility, size, and purchasing power of the market. If the urban center were suddenly to be removed from the space it occupies, it seems doubtful that the spatial arrangement of farms would remain the same.

Where, then, should an urban boundary be drawn? Should it encompass only high density areas or should it include farm belts as well? Should there be a mixed zone (a semi-urban area) between city and adjacent farm area? Some type of metropolitan statistical (rather than political

[19] E. Jones. *Towns and Cities* (New York: Oxford University Press, 1966), p. 7.

[20] Jean Gottman. *Megalopolis* (Cambridge, Massachusetts: The Massachusetts Institute of Technology Press, 1961), Chapter 6, passim.

administrative) definition, based on national considerations and attitudes, is needed. If a large city grows and takes over additional territory at its edges, new data are recorded at the expense of whatever rural population may reside in the newly acquired area. Has this new "urban" population really changed? Do the farmers engage in a different kind of farming because of the addition? It is important for the data users to know what is included in the concept and what types of land use and economic orientation are involved in an area which has both urban and rural characteristics. Administrative boundaries are not very helpful in this regard.

5.4 Industrialization in rural areas

The tendency for industry to be located in or near urban centers highlights the fact that few rural areas outside a city region seem to be able to attract industry. Exceptions to this, to a degree, would be cottage and craft industries or factories that are raw-material oriented, such as sugar refineries. Thus, rural areas within city regions can expect some possible industrialization, whereas rural areas outside city regions are in a much poorer competitive position to attract industry. Attempts to bring industry to the rural areas are therefore spatially restricted. The building of so called "new" cities is normally no more than the establishment of satellite centers in desirable parts of the city region.

6. ECONOMICALLY ACTIVE POPULATION IN AGRICULTURE

The economically active population in agriculture is often hard to define. Participation rates are not clear since unpaid family workers are often involved. Some countries restrict data to males of certain ages, but there is no consistent treatment. In some cases, an entire family is designated as being engaged in farming if the head of the household is so employed, yet some persons in the family may work gainfully on a full- or part-time basis in non-agricultural activities. Definitions in some countries may be based on an agricultural holding rather than a household. Landless peasants may sometimes be excluded from an agricultural census. Finally, unemployment figures are particularly inadequate for clear analysis. For this last reason, the FAO Indicative World Plan did not set specific employment targets. It is well to keep these data limitations in mind in characterizing or measuring the economically active population in agriculture.

6.1 Labor problems

In fairly specific terms, there appear to be four major labor problems in agriculture in developing countries. First, there is the excess of labor which should be employed elsewhere if possible. Second, seasonal fluctuations in labor demand are often very high. The job market, therefore, is typically one of feast or famine. Third, landless workers, who are at the lowest step of the employment ladder, are completely at the mercy of labor demand fluctuations. Fourth, short-lived labor shortages often appear at key peak periods during the agricultural cycle; in other words, even in the midst of labor plenty, demand can suddenly exceed the supply of labor.

Since the capacity to absorb farm labor into the non-agricultural sectors of the economy often appears to be limited, the problem is a serious one. The Swedish economist, Gunnar Myrdal, suggests that the hope of developing countries to employ large numbers of workers outside of agriculture is not realistic.[21] Part of this argument is based on the fact that high capital costs are often involved in creating modern industrial employment. The situation is made worse by rapid rural population increase, since the efficiency of agriculture often seems to be oppositely related to the proportion of the economically active employed on the land.

6.2 Underemployment

More people work in agriculture than in any other type of activity. The numbers are very large in some countries. Although over half of

[21] Gunnar Myrdal. *Asian Drama* (Harmondsworth, Middlesex, England: Penguin Books, 1968), p. 1242.

the economically active population may be engaged in agriculture, they usually are not able to contribute their share of the Gross Domestic Product. In some developing countries, the average production per worker may be rather low. During World War II, half of the farm labor force in Rumania was drafted into the armed forces and yet food production did not fall. Examples of this kind suggest clearly that agriculture is greatly overstaffed. The President of the World Bank estimates that, as of 1960, over one-third of the agricultural labor force in Latin America was underemployed.[22]

Some estimates have been made of the degree of underemployment in certain countries and the problem created by intermittent labor demand. In one study, the estimated labor demand in man-hours for each month of the year was calculated for different types of farm operations and areas. These figures were weighted according to the age and sex of the local population and then compared to the number of man-hours available. The results not only clearly showed the degree of underemployment, but also illustrated the fact that during periods of peak farm activity, actual labor shortages existed.[23] This is apparently a common occurrence in many agricultural areas in the world.[24]

6.3 Solutions

Solutions are not easy to find. For example, one might suggest multiple cropping or crop combinations whose labor demands support rather than compete with each other, thus equalizing the need for workers throughout the year. Needless to say, the necessary physical conditions, crop combinations, and suitable markets for the products are often hard to find.

Out-migration is another type of response to the problem. As discussed earlier, the benefits of this movement are largely lost because of the high prevailing rural population growth rates. Perhaps a better rural educational system organized more to non-urban than to urban life and needs would also help. Making changes in a traditional peasant society, however, is usually very difficult. It is relatively easier to change life styles among uprooted rural folk living in cities.

In some places, agriculture as an occupation is combined with fishing, as in Norway; with industry, as in Japan; or with forestry, as in Paraguay. Despite this, few opportunities for work outside agriculture offer themselves in overpopulated farm areas. Occasionally, a government can organize a labor force to help in such public works as building roads, schools, public buildings or storage facilities, or in installing irrigation and drainage lines, digging wells, grading fields, or controlling erosion. Capital is normally needed for such work, although some modest efforts have been made to enlist volunteer farm labor for undertakings of this kind.

7. SUMMARY

It appears as though future population distributions are going to stay about the same as they are now. Most nonecumene areas will remain empty and certain frontier zones will experience a modest influx of people. It is probable that urbanization within the ecumene will continue.

The total numbers of people in rural areas will probably not decline for some time, if at all. This is due to population increase, the high capital costs that are often involved in creating non-farm employment, and the inability of cities and industries to absorb excess farm labor.

Although some industry can be established in city regions, outlying agricultural areas appear to have less potential in this regard. The problem thus revolves around the inability of many nations to provide gainful employment to people in the over-populated countryside. The problem is compounded by rapid rural population growth.

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[22] Robert S. McNamara. *One Hundred Countries, Two Billion People* (New York: Praeger Publishers, Inc., 1973), p. 62.

[23] Robert E. Dickinson. *Population Problem of Southern Italy* (Syracuse, New York: Syracuse University Press, 1955), pp. 66-82.

[24] Dana G. Dalrymple. *Survey of Multiple Cropping in Less Developed Nations* (Washington, D.C.: U.S. Government Printing Office, 1971), pp. 44-45.

Chapter 3. AGRICULTURE

1. INTRODUCTION

The argument has been commonly advanced that manufacturing industries contribute more to the Gross Domestic Product of developed countries than does agriculture. Many developing nations therefore have viewed industrialization as the best means by which an economy can be expanded and improved. Agriculture has been considered a secondary and less significant type of activity. Accordingly, the social and economic image is such that agriculture often is held in low esteem in many countries.

Some nations, however, have begun to change their attitudes and policies regarding agriculture, particularly in the past decade. They have concluded that, while the potential for industrial and commercial development may be good, it is imperative that other segments of the economy should be improved simultaneously. In this view, concentration on one aspect, to the detriment of others, is undesirable.

A number of countries have adopted an agriculture-first policy in determining the direction and thrust of their economic growth plans. This decision, in part, has been an outgrowth of the demands for more food due to rapid population growth and the desire for foreign exchange obtainable from the sale of agricultural goods.

It is the purpose of this chapter to examine the characteristics of agriculture and to help assess its potentials and problems. In addition, various forms of agricultural development are discussed.

2. DATA USE

Users of agricultural statistics should be particularly aware of problems relating to the definition of terms and the comparability of data. For example, if the per capita income for a developing country is given in U.S. dollar equivalents, the data user is then unknowingly led into making a comparison of purchasing power between the two countries. The conclusions he draws from this may be misleading. Few people in the United States could survive over a long period of time on an income of $100 per year. By contrast, this same income, although exceedingly low by U.S. standards, is enough to sustain many individuals in some countries. Similarly, comparisons of arable areas may not be easy to make. A populous country with a great deal of land pressure may consider land cultivatable which the farmers in a better endowed country would not. Further, the arable area in the latter nation could readily change. Suppose that its government decided to attempt to grow as much of its food as possible. In such a case, idle or non-agricultural land might be pressed back into service. What is potentially arable depends upon many considerations, such as transportation, accessibility, irrigation, and clearing and drainage costs.

As indicated, the definitions of terms can present problems. A few additional examples may emphasize this point. Distinctions made between the terms "laborer," "tenant," "sharecropper," and "owner" are not always clear; therefore, an individual can be classified in more than one way. The meaning of the word "fallow" may vary according to local custom, type of farming, and climate. The terms "temporary meadow," "pasture," and "cropland" are often vague, so that it may be difficult at times to assess the quality of land consistently and accurately. The definition of a farm can be especially critical for data users. If criteria such as the size of the holding or

the value of sales off the farm change, the statistics will not be comparable from one period to another. Thus, the data user suddenly may be confronted with the appearance of a large number of "new" farms or the "disappearance" of many old farms. Finally, part-time or subsistence farmers may or may not be counted, depending on the accepted definition.

The data user also should be aware that some statistics are more reliable than others for a variety of reasons. A respondent might wish to provide an enumerator with little or misleading information, fearing that his taxes might be raised by the government or that he might be evicted from the land by the owner. Local laws also might affect the reporting of data. Put simply, if sharecropping were illegal, few sharecroppers would report themselves as such. Farmers may also be poor record-keepers and it is often difficult to obtain accurate data about crops which they produce and consume themselves.

Statistics usually are reported by administrative areas; therefore, data for an economically and geographically defined crop region which does not coincide with political divisions may be inaccurate. For example, the data might indicate that annual forest growth and cut are equal, when in fact the more accessible regions are being overcut.

3. *LAND CLASSIFICATION*

Land may be classified according to its ability to support a certain type of agriculture. Land capability (or potential) and actual land use do not always coincide. This is due to the many other variables which affect decision-making in regard to agricultural land use in any area. Patterns of actual land use can be based on existing crop patterns and rotations, and on animal husbandry techniques. Other classifications can be made based on such physical or non-physical (cultural) features as farm size and tenure, length of growing season, predominant crop, crop combinations, market opportunities, institutional factors, or slope. The large number of variables makes it difficult to categorize land-use areas.

Usually, field work is performed on a micro-geographic basis in which studies of comparatively small areas are made. The results are often mapped as well as described. It is possible that remote sensing imagery[25] will permit a great advance in this type of work, although most current research of this kind is being done for relatively large, rather than small, areas. The use of the new imagery might help lower the costs of future surveys.

The utility of land-use surveys is limited, to a certain degree, by the original objectives of the people who made the studies. Unfortunately, few surveys can satisfy the needs of all types of users. A few examples of well-known surveys are listed below.

(1) A World Land Use Survey was promoted by the International Geographical Union shortly after World War II. Its purpose was to develop maps and reports of land use on a world-wide basis. The survey ran into major problems, one of which was the attempt to standardize agricultural land-use categories.

(2) The U.S. Soil Conservation Service has developed a land capability classification which divides areas into eight categories, based on suitability for cultivation. This classification focuses on physical rather than cultural features of the landscape.

(3) The Land Utilization Survey in Great Britain, some three decades ago, adopted the policy of identifying areas of good farm land which, if at all possible, should be protected from non-agricultural land use. A certain degree of independence was allowed within the major political areas of Great Britain. For example, what was considered first-class land in Northern Ireland was not necessarily so classified in Scotland. Distinctions were thus allowed to remain, since the major use of the study was to provide information for purposes of local planning, rather than for comparison with other nations.

(4) The U.S. Tennessee Valley Authority (TVA) developed a system of land-use classification which subsequently served as a model

[25] Representation of data by systems which are not in direct contact with the subject being investigated; for example, an aerial photograph of a rural area or a satellite image showing temperature of land areas.

for other surveys, both in the U.S. and elsewhere. It classed small-unit areas in terms of a code expressed in the form of a fraction. The survey dealt with such items as field size, amount of idle land, quality of farm buildings and equipment, drainage, soil fertility, and slope. Its major disadvantage as a survey tool was the cost and time it took to develop. In addition, the large number of items classified for each area did not permit easy comparison with other areas.

(5) Some attempts have been made to quantify classification schemes. The U.S. Soil Survey, for example, has established productivity ratings based on crop output by soil type. However, in addition to physical characteristics, yields reflect cultural factors such as management or skill. Accordingly, the ratings tend to reflect actual conditions rather than the productive potential of the land.

Despite the problems and the costs involved in developing a land-use survey, the resultant information can greatly facilitate work in economic planning. If a nation wishes to increase its agricultural output, a knowledge of land-use capability is essential.

4. PROBLEMS OF AGRICULTURE

Persons who believe that agriculture is not a very important segment of the economy point out that, in a developed country such as the United States, agriculture contributes only about four percent to the Gross National Product (GNP). This belief ignores the fact that, if the United States farm output of raw materials was significantly decreased and farm imports had to be substantially increased, much of the country's economy might have to be considerably restructured. Certainly the very important food processing industry would have to undergo change.

Another argument is that most countries with a strong agricultural base and little else are not very prosperous. Denmark and New Zealand have high living standards, so the argument goes, not because their agriculture is flourishing, but rather because they are closely tied to the industrial economies of other countries. This seems to ignore the positive contribution which a vital farm base can make to the economy; it also neglects to take into account the fact that agriculture has actually helped to develop a prosperous industrial mix in many countries. It is not an uncommon procedure for a government to purchase domestic farm products at fixed, low prices and then export them at a profit. However, as stated earlier, agriculture does not contribute its share to the GNP of many developing nations, given the large size of the farm labor force; it is also true that average income per capita in agriculture is generally lower than it is in non-agricultural activities.

The economic weakness of agriculture can be accounted for in several different ways.

(1) Man's control of nature is limited. Due to the erratic impulses of nature, the size of a crop is never certain until it is harvested. Compared with industry, agriculture has less control over production; thus it cannot adapt as quickly to fluctuations in demand. Tree crops, for example, require a number of years before maturing. If demand does not continue to increase, the output from new plantings eventually results in oversupply and a consequent drop in prices. This has happened in coffee production a number of times. Furthermore, demand for most farm products is not flexible; therefore, a decrease in price does not necessarily result in the increase in demand as is likely the case with industrial goods.

(2) Reduction in demand has little effect on fixed costs, which are often high and represent a substantial portion of total costs. It is often difficult for commercial holdings to meet high overhead costs when the market price of the product falls.

(3) Agricultural returns on investment generally are not as profitable as are those from non-agricultural activities. As a result, in most cases, it is only the farmer who invests in his holding. While some agricultural processing industries have invested in farm enterprises, such action is possibly less motivated by direct profit incentives than by a variety of other factors such as tax considerations, more effective control over production, or investment in land for future development.

(4) It is easy to oversupply the market during good years, since the large number of small producers are forced to sell their crops at harvest time at decreased prices.

(5) Even fairly large holdings usually are moderate in size compared to many non-agricultural enterprises. Thus, small retail establishments in a central business district of a city may require a larger amount of capital than many commercial agricultural holdings. Furthermore, there are many industries of

only moderate size with investments comparable to such large agricultural holdings as that of the King Ranch in Texas (370,000 hectares), or the Alexandria Station (ranch) in Australia (2,935,000 hectares). This argument can be further strengthened by pointing out that the family enterprise is far less significant as a common productive unit in manufacturing than it is in agriculture. In addition, since the number of agriculturists is small, research and development activities become the function of an agency of the central government; accordingly, new discoveries are the property of all.

(6) Agriculture faces considerable competition from synthetics such as artificial fibers or rubber.

(7) There is a tendency for the gap to widen between the prices farmers receive for their products and the costs of the goods which they must purchase. In other words, over a period of time, the farmer presumably must sell more beef in order to buy the same tractor. Moreover, the farmer has little control over the prices that are offered for his products. There is some thought that international commodity agreements could change this situation, much as the oil-producing nations seem to have done; however, there is no real evidence to suggest that agricultural or other producer organizations could exert such control over the pricing mechanism of their products.

5. GENERAL CHARACTERISTICS

Many different views are held regarding the importance of agriculture. Some observers highlight its positive aspects and contributions. Others suggest that it cannot be very important since it is by nature subordinate to other sectors of the economy. Those who hold such a view maintain that modern industry can raise national income to a greater degree than can agriculture. Great Britain, for example, has depended upon food imports for a long time, and yet has maintained a high standard of living for its inhabitants.

The opinion that agriculture is subordinate implies that agriculture does not have the capability to improve the economy of a country substantially; it also implies that investment in agricultural development is not worth the cost. Whether this point of view is a valid one or not, it does ignore the increasing need for food in a world with a rapidly expanding population.

Often it is difficult to categorize agriculture in terms of such characteristics as size of holding, tenure practice, and yields. Large holdings are not necessarily efficient; tenure does not have to be associated with rural poverty; and high yields are not always associated with efficient, low-cost farming units.

5.1 Types of farming

There are two different divisions in agriculture which should be explained briefly. The first is that between subsistence and commercial agriculture; the second is between intensive and extensive farming or ranching. The kind of agriculture practiced often depends on the climate and on other natural conditioners. Nevertheless, the decision as to the type of farming or ranching involved can also reflect cultural factors. Thus, some countries have large, under-utilized estates where animals are grazed, despite the availability of labor and a capability to increase productivity. Conversely, a relatively prosperous agriculture may be found in areas with less than ideal climates and soils.

5.11 Subsistence and commercial.--There are far more subsistence than commercial farmers in the world. The subsistence farmers consume most of what they produce. Only if their internal needs are met is any surplus sold off the farm. Sometimes, even surpluses are stored and consumed by the producer. Thus, in many countries, a large proportion of the crop grown during a good year may not find its way to market. It should be pointed out, however, that the subsistence farmer often finds it very difficult to sell his surplus if he is forced to transport it a long distance to the nearest market. Thus, he is part of the non-exchange economy through circumstances--not by choice.

It is not the intention of the foregoing to suggest that the traditionalist type of farmer never sells anything off his farm. On the contrary, he must often sell some part of his crop in order to purchase necessities which he cannot

produce himself. Only very primitive and poor people, with almost no contact with the outside world, are absolutely self-sufficient.

Generally, however, the subsistence farmer lives outside the money economy of the nation. He requires little from it and produces little for it. He does not plan carefully or consciously for the market. He may have little desire to increase his output, or he may not actively seek to obtain maximum income. Once a level of living is attained which he considers desirable, the farmer may have little further inclination to increase production. One analyst claims that the introduction of a high-yield variety of seeds which would double the size of a crop will be readily accepted by some farmers only because they will then assume that they need to cultivate only half their normal land area.[26] Of course, this attitude does not apply to all farmers. It should be kept in mind, however, that successful agricultural development implies an exchange economy in which there is a substantial output and market demand for farm products. By contrast, many traditional farmers are motivated by non-economic factors in making decisions regarding production. It appears, though, that once subsistence farmers accept a commercial way of life they seldom change back to their original traditional habits and customs.

Commercial farming involves the production of agricultural goods for sale. Almost all of the necessary inputs (food, fuel, equipment, fertilizer) are purchased, and the variety of crops is smaller than on the subsistence farm. The products of this modern, rather than traditional, type of agriculture enter into world trade channels. In many cases, the size of the land area involved does not seem proportional to the impact which these commercial farmers have on the economy. There are various degrees of this type of farming, ranging from partial subsistence on the one hand to completely commercial orientation on the other. Thus, many small, part-subsistence farmers in some countries are turning more and more to growing plantation types of crops. One economist suggests that the dividing point between the two types of farms is a production of about 300 to 400 kilograms per person per year of grain equivalents.[27] Above this amount, the farmer will increasingly become commercially oriented.

Within this framework, one analyst makes an interesting observation concerning differences in commercial agriculture. In North America, he maintains, farms are often referred to as "profitable"; whereas in Europe, there is more of a tendency to think of them as "productive."[28] This may be partly due to the greater emphasis and desire for economic independence in Europe. This focus on economic self-sufficiency with respect to food production generally is accompanied by a substantial support of agricultural operations by the government.

There is no precise, sharply defined boundary between subsistence and commercial agriculture; rather there are stages in which one type or the other predominates. Although there are comparatively few subsistence farms which are completely self-sufficient, a higher percentage of commercial operations concentrate solely on sales.

5.12 Intensive and extensive.--Intensive farming normally requires a considerable input of labor, and the yields per hectare are high. On the other hand, extensive farming does not involve as much labor per productive unit, and yields per worker may be high. Intensive agriculture often is associated with small plots, irrigation, high-carrying capacity, or humid climates. It is not the size of the holding that normally induces intensive agriculture practice, but the existence of a good market or population pressure.

Extensive operations are more commonly linked to large holdings, semi-arid climates, lack of

[26] Dana G. Dalrymple. *Survey of Multiple Cropping in Less Developed Nations* (Washington, D.C.: U.S. Government Printing Office, 1971), p. 57.

[27] Colin Clark. *Population Growth and Land Use* (New York: Macmillan Co., 1967), pp. 139-140.

[28] Rene Dumont. *Types of Rural Economy* (London: Methuen and Co., Ltd., 1954), p. 520.

land pressure, labor shortages, and mechanization. It might be contended that extensive farming is capital-oriented and intensive farming is labor-oriented. The line of separation between the two, however, is not always clear. For example, paddy rice production in the Philippines and dairying in the Megalopolis in the United States can both be considered intensive forms of farming; one is labor-intensive and the other is capital-intensive.

5.2 Size of holdings

As a general rule, the average size of holdings in developed countries has tended to become larger, so that certain economies of scale are achieved. Nevertheless, it need not be assumed that small holdings are bad. Certainly the minifundia, or very small plots of land, are wasteful of time and effort and are almost impossible to irrigate or dry-farm successfully. Yet small farms can often be efficient if their location and the physical endowments are favorable. This is particularly true if markets are good and crops are raised which require a considerable amount of labor per hectare. Irrigated land also can be divided into small efficiently run plots. In Mainland China it was commonly the case before the Civil War that a farmer could make a living on less than five hectares of good land, but would starve on 50 hectares of marginal land. Size then is not the sole determinant in evaluating success in farming.

Latifundia, or large, under-used holdings, are usually the source of strong public feeling. In Latin America, for example, the average latifundia is 400 times as large as the minifundia, yet it does not employ a proportionate number of workers. These holdings should not be confused with estates which must be large because the carrying capacity per animal is low. Often laws and administrative efforts are made to force latifundia owners to use their land more intensively. Such efforts generally lead to increased production and employment. Nevertheless, in many cases, the owners have no desire to spend much time, effort, and capital on the holding; they may own the land for social rather than economic reasons, or they may be using it solely as a protection in case of economic inflation. In any event, such owners attempt to evade the laws which would force them to use the land more intensively.

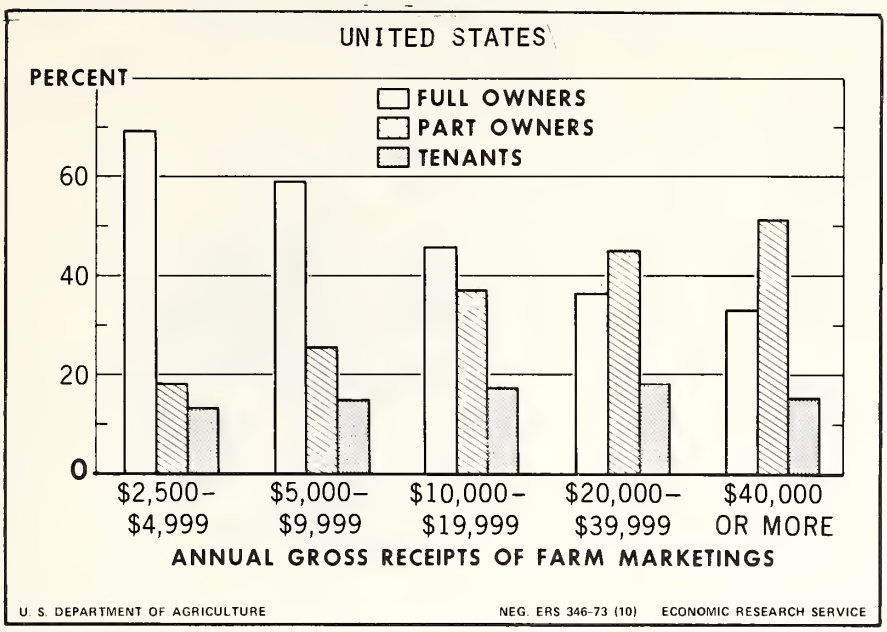
A major problem of agriculture in relation to size is fragmentation. For example, a 2- to 3-hectare holding in Asia may have up to 20 separate strips, located at considerable distances from each other; a major portion of the day may be spent simply traveling to each plot. This can be particularly disadvantageous during periods of peak labor activity. The average holding in India is under 2 hectares and consists of 5 to 10 plots, some of which may be as small as 1/400 of a hectare. Many areas of the world suffer from this problem. Attempts at consolidation have been made, notably in India, with mixed success. On the whole, farmers are reluctant to trade their plots for others which they commonly consider to be inferior in quality.

5.3 Tenure of holdings

Ownership of the land is usually regarded as a favorable practice, since it is presumed that farmers will work harder on land which they own; tenants and share-croppers are not likely to be as interested. Whereas this statement may be true in many cases, it ignores the fact that the conditions of the tenure, rather than tenure itself, are undesirable. For example, a very successful form of tenancy has been associated with the prosperous United States Corn Belt for some time. Farm land in that area is of high quality and often is too expensive to purchase; therefore, much of it must be rented. The terms of the agreement are such that the tenant has an interest in maintaining and improving the farmstead. In the United States, it may be noted that there are a sizable number of tenants and part owners among the most prosperous farm grouping, as shown in figure 3-1. Similar conditions may be found in parts of Great Britain and in other countries.

It must be admitted that tenancy, either through renting or sharecropping, is usually associated with poor farm practices in most agricultural areas. In places where land pressure prevails,

Figure 3-1. TENURE CHARACTERISTICS BY ECONOMIC CLASS OF FARM



Source: 1969 Census of Agriculture.

landless peasants compete to obtain a farm plot. To be without land is often to risk starvation. Since tenants may be evicted the next year, and since there are few incentives for them to develop the holding, they make little attempt to maintain soil quality, prevent erosion, repair farm buildings and equipment, or otherwise invest in the land they farm. The tenancy agreement may be such that the renter or sharecropper profits less from an increase in farm prices than does the owner. Also, it may contain terms which keep the worker in constant debt to the owner, even if the worker is allowed to remain on the land for an extended period of time. Often the landlord may receive a large share of the harvest, but will not pay for any new inputs to raise productivity. Many countries have attempted to adopt reforms which provide for security of tenure, regulate and reduce rents, and furnish tenants with the means by which they can become owners of the holding. However, such reforms are not always successfully implemented. Nevertheless, land reforms in such countries as Taiwan, Egypt, and India have increased the number of farm owner-operators.

Ownership of land in peasant societies is highly prized. One form of ownership in certain cultures is communal in nature. It is found in South and Southeast Asia, sub-Saharan Africa, and Latin America. The Indian ejido of Mexico and Ecuador, the Israeli kibbutz, and the Tanzanian ujamaa are all forms of communal operation of land. Each has its own distinctive features.

Large-scale collective or state farms are commonplace in Communist countries. They seem to have met with indifferent success, given the fact that the output from the small private plots owned by the workers on the collectives contributes far more than its proportionate share of total production. As one observer puts it, "Undoubtedly the single most important factor responsible for low yields...is the system of state and collective farms."[29] It is estimated that private plots in the People's Republic of China cover 5 percent of the cultivated land but produce 20 percent of the food.[30] Some socialist regimes, such as Poland and Yugoslavia, have been somewhat more practical in putting their ideology to practice, at least as far as collectives are concerned.

5.4 Crops and animals

Crop and animal choices are based on economic, social, and political factors as well as on physical conditions. The latter are easy to visualize. Potatoes do well in an acid soil whereas many other plants do not. Vineyards are often found on slopes so as to avoid frost damage. High-grade tobacco requires a certain type of soil not found everywhere. Cotton must have a 200-day growing season and a dry period before harvesting. Sisal does well under semi-arid to arid conditions, whereas water requirements for rice are fairly high. Cane sugar requires a frost-free climate, but beet sugar is not so demanding. Few plants are able to exist under highly varied natural conditions.

[29] Lester R. Brown. *Increasing World Food Output* (Washington, D.C.: U.S. Government Printing Office, 1965), p. 66.
[30] M.R. Larsen. "China's Agriculture Under Communism," in U.S. Congress, Joint Economic Committee, *An Economic Profile of Mainland China* (Washington, D.C.: U.S. Government Printing Office, 1967), p. 1260.

Given such physical constraints, the possible choices of types of cultivation still may be numerous. Thus, a prime agricultural area such as the United States Corn Belt could be cultivated to many kinds of crops and combinations. Its current use, in which a meat product is the end result of the agricultural cycle, reflects the desires, tastes, and income levels of the American public. Many types of agriculture depend upon such cultural (non-physical) variables as markets, accessibility, profit incentives, farmer skills and attitudes, availability of inputs, support services, and government policies.

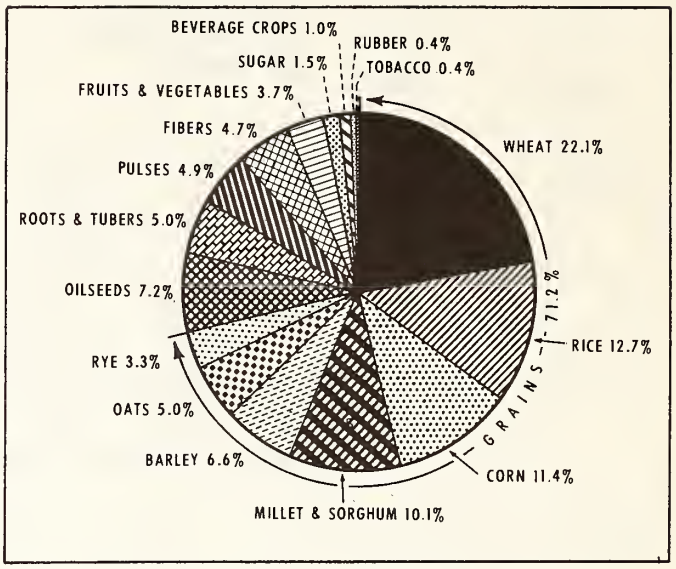
In some parts of the world, rice is grown in areas which, in terms of physical characteristics, could be cultivated to some other crop; however, rice is the crop that is grown because of its high caloric content per hectare. As one observer puts it, "Rice is thus the cereal which allows the greatest number of people not to starve on the smallest possible space."[31]

In areas with land pressure, there is some competition between food and feed crops and between food and industrial crops such as oils or fibers. In Java, cotton could be cultivated but the general preference seems to be to grow rice and to import the fiber; by contrast, Egypt grows cotton in areas where food crops might be raised. Nevertheless, despite the importance of industrial crops, which is out of proportion to the number of hectares devoted to them, edible crops occupy far more farm area. As shown in figure 3-2, the amount of land devoted to industrial crops, such as fibers and rubber, is comparatively small for the world as a whole.

As with crops, the choice of animals depends on a number of factors. Animals can be bred for meat, milk, hides, wool, or for draft purposes. In many developing countries, they are multi-purpose; in such cases, the animals are often hardy native types but are not particularly efficient producers of animal products or power.

[31] J. Beaujeu-Garnier. *Geography of Population* (New York: St. Martin's Press, 1966), p. 55.

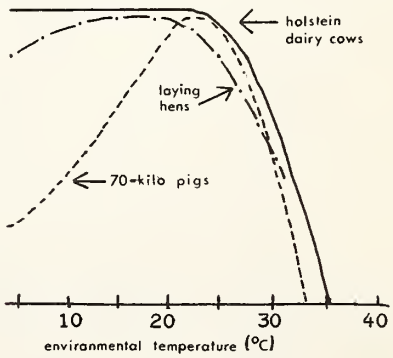
Figure 3-2. WORLD HARVESTED AREA OF PRINCIPAL CROPS (Excluding forage and fodder crops)



Source: Man, Land, and Food. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 11. November 1963.

Unmixed, imported, high-quality breeds must often be replaced in some areas with the passage of time. Dairy animals, for example, often do not retain high-yield qualities in the tropics after the second or third generation. Increasingly, then, attempts are made to cross-breed high-yield stock with native breeds which are acclimated to local conditions. Temperatures also have an effect on animal production (see figure 3-3).

Figure 3-3. INFLUENCE OF ENVIRONMENTAL TEMPERATURE ON PRODUCTION OF PIGS, COWS, AND HENS

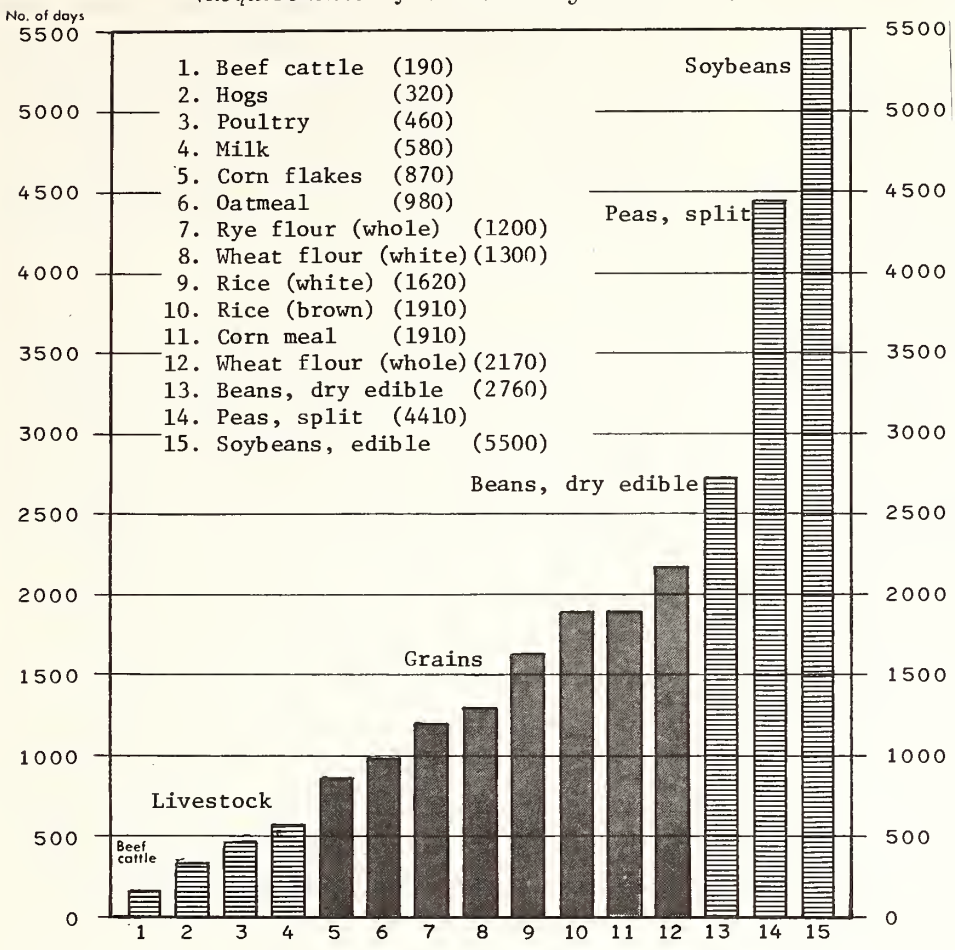


Source: Power to Produce. U.S. Department of Agriculture Yearbook. 1960.

In some cases, animals are kept for religious or prestige purposes and are closely related to the culture of the area. Such animals are not particularly productive, although they may be by

Figure 3-4. NUMBER OF DAYS OF PROTEIN REQUIREMENT PRODUCED BY ONE HECTARE, YIELDING SELECTED FOOD PRODUCT

(Requirements of a moderately active man)



Source: From Bean, L.H. WHO/FAE/UNICEF Protein Advisory Group News Bulletin No. 6: 20-31. April 1966.

no means useless. For example, it is estimated that the heat produced by burning cow dung in India is equivalent to 35 million tons of coal.[32]

One observer has suggested that attempts should be made to breed disease-resistant wild animals which can graze on fairly poor land and which can yield more meat than many domesticated species can produce.[33] In this case, some types of African antelopes and large South American rodents are mentioned.

There are more than 6 billion farm animals in the world, about half of which are poultry. Approximately 60 percent of the world's non-poultry animals are found in the developing countries; yet developing nations produce less than a third of the world's non-poultry products. There is definite potential for increasing this yield through improved animal husbandry techniques and disease control. The United Nations Food and Agriculture Organization estimates that, if the losses now occurring due to animal disease alone were cut in half, protein production would be increased by roughly 25 percent.[34] Meat, eggs, and milk are highly perishable commodities, however, and they often require complex processing, marketing, and distribution systems. Technological improvements in production, therefore, must be considered within the context of social, economic, and political considerations. Furthermore, disease and parasite control itself probably indicates the existence of an adequate transportation system, skilled personnel, and good range and forage management.

Animal products are more expensive than vegetable products. This is because animal products require more time to mature and because animals are inefficient converters of caloric energy. Additionally, only a small proportion of the feed consumed by animals is usable for human consumption. Thus, approximately 8 kilos of alfalfa or 7 kilos of grain are required to produce 1 kilo of beef. Expressed in another way, one-tenth of a hectare of sugar beets or almost four-tenths of a hectare of wheat can produce the same number of calories as 4 hectares of feed crops and pasture.

[32] P.R. Ehrlich and A.H. Ehrlich. *Population, Resources, Environment* (San Francisco, California: W.H. Freeman & Co., 1970), p. 88.

[33] Hans H. Landsberg. "Population Growth and the Potential of Technology," in *World Population--The View Ahead*, ed. by R.N. Farmer, J.D. Long, and G.J. Stolnitz (Bloomington, Indiana: Indiana University Press, 1968), p. 181.

[34] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, pp. 90-91.

A country with a land pressure problem may suffer from this type of production, which could take many times the amount of land to feed a meat eater as opposed to a vegetarian.

Figure 3-4 (shown on the previous page) is an illustration of 1-hectare yields of selected vegetable and meat products in terms of their protein values. At one extreme, 1 hectare of soybean production will provide one man with his daily protein requirement for more than 15 years (5500 days); at the other extreme, that same amount of land devoted to feed cattle will produce only a half-year (190 days) supply of the protein needed by that same man.

Some techniques can be developed which can satisfy the needs of both meat eaters and vegetarians. For example, certain livestock could be kept which would consume vegetable wastes or by-products, thus cutting down on the amount of land needed to support them. The new method of feeding urea directly to animals, rather than using it as a nitrogen fertilizer, may also cut down on the inputs of land needed to feed animals.

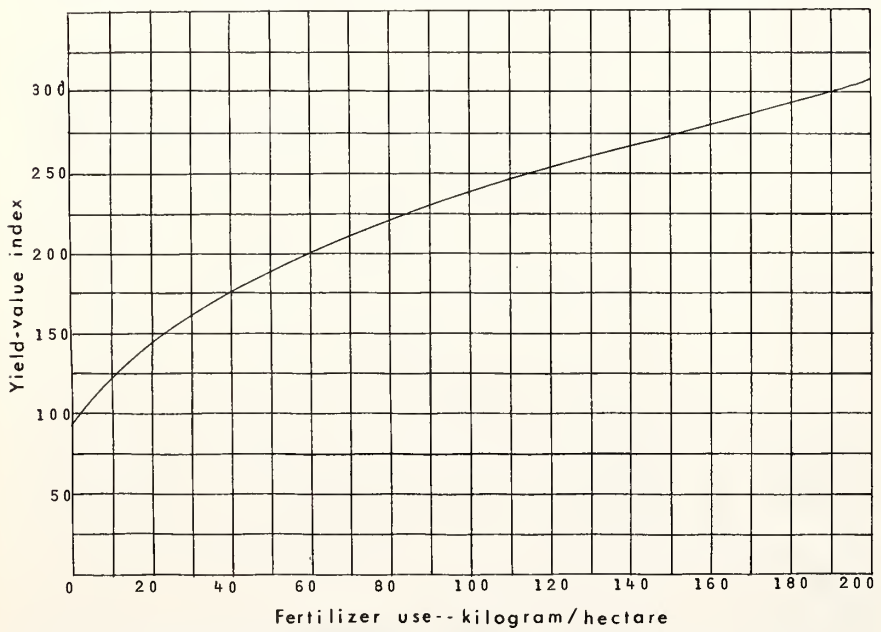
As noted, vegetable output per unit of land can be relatively high. For example, one-tenth of a hectare in 19th Century Ireland could supply over 6 kilos of potatoes per day to meet the needs of a family of six. Some food crops are naturally more effective calorie producers than others; thus, grain output from rice is normally 2 to 2 1/2 times that of wheat. Accordingly, a growing population in a land-short country probably would concentrate on high-yield crops, such as rice or sweet potatoes, and convert pasture to arable land if possible.

5.5 Fertilizer

Increases in yields throughout the world are linked closely to the degree of use of fertilizer; on the other hand, production seldom can be maintained or raised without fertilizer in some form. One administrator in the Department of Agriculture points out that output per hectare in the United States has increased 50 percent since 1940 and that almost half of this amount can be accounted for by increased application of fertilizer.[35]

Figure 3-5 shows the relationship between yields and use of fertilizer. It should be pointed out, however, that the use of fertilizer is only an indicator of a combination of materials and techniques, since the use of more fertilizer is usually accompanied by the use of better seed, more pesticides, and other improvements.

Figure 3-5. YIELD-VALUE INDEX VERSUS FERTILIZER USE: 1961/63



Source: The World Food Problem, Volume II. A Report of the President's Science Advisory Committee. May 1967.

Currently, world production and consumption approximate each other. As might be expected, the developed nations use considerably more fertilizer. For example, as of 1972, the developed nations consumed almost twice as much nitrogen, over three times as much phosphate, and over six times as much potash as the developing nations. It is encouraging to note, however, that recent consumption patterns in developing countries show an increase of about 10 percent per year. Nevertheless, there are major problems of production, financing, training of farmers, and distribution. Some countries must import all of

[35] Quentin M. West. *World Food Needs* (Washington, D.C.: U.S. Government Printing Office, 1966), p. 7.

their requirements, and others do not have the transportation facilities needed to distribute the fertilizer.

If developing countries applied as much fertilizer as the advanced nations, the present total world production of fertilizer would be inadequate. For example, if India were to use as much fertilizer per hectare as Japan, India would consume more than the current total world output.[36] It is estimated that doubling of agricultural production by 1985 would require almost an eightfold increase in fertilizer consumption (over the 1972 figures) for developing nations, excluding Mainland China.[37] However, there seems to be little possibility for a great increase in the use of fertilizer in the near future, since there are many factors working against it.

Applications of fertilizer and insecticides cannot be made at random. Soil types, climate, plant needs, and timing must all be considered. For this reason, applied research must be specific in order to be able to deal with local needs and problems. Farmers must be trained in terms of application and needs for their specific areas. For the most part, fertilizers and insecticides are more effective if they are used at the right time and place and in the right amounts. The magnitude of this job suggests that a large and well-trained service is needed and must be available locally.

Concentrated and increased application of fertilizer in the future will likely bring about pollution problems. Similarly, greater use of insecticides, fungicides, and herbicides will add to the pollution, and this increase may be substantial. In order to double food production in the developing world, it is estimated that a sixfold increase of herbicide use is needed.[38]

Finally, the use of fertilizers, insecticides, etc., may also affect labor demand. For example, herbicides can cut labor needs for weeding if they are used effectively. This may be helpful if major weeding chores occur during times of peak demand for labor.

5.6 Mechanization

Two opposing views often are taken regarding the desirability and impact of mechanization of agriculture in developing countries. On the one hand, the Director General of the United Nations Food and Agriculture Organization states that, "The crucial dilemma may lie in the fact that the very measures that might raise productivity and economic growth most rapidly both in agriculture and in many industries could lead as well to a reduction rather than an increase in requirements for human labor."[39] In areas of agrarian unrest, land owners have often used the possibility of introduction of machinery as a threat to silence the opposition from farm labor elements.

On the other hand, it can also be maintained that mechanization, all things being equal, increases production and helps develop a workable and prosperous agricultural base. This view assumes that additional inputs are available, that the farm labor force is trained and skilled, and that the size of holdings can accommodate the machines efficiently and effectively. Also, it ignores the problem of the displaced farm population and thus focuses almost solely on an economic solution whose goal is to increase production and income for those involved in the work. Persons holding this point of view believe that little can be done for the poor farmer and laborer and that, if the nation becomes prosperous, it could then provide some financial assistance for these people. Such a proposal neglects the social and political dimensions of the problem, and is therefore not always realistic.

Accelerated movement of unemployed persons to cities might have unfavorable effects. India has considered accommodating its excess farm

[36] Gunnar Myrdal. *Asian Drama* (Harmondsworth, Middlesex, England: Penguin Books, 1968), p. 1289.
[37] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, p. 86.
[38] Ibid, Vol. I, p. 86.
[39] Addeke H. Boerma. "A World Agricultural Plan," in *Food,* ed. by J. Hoff and J. Janick (San Francisco, California: W.H. Freeman & Co., 1973), p. 217.

population by developing labor-intensive small industries and increasing the number of public works projects which focus on community-level construction of health centers, schools, local roads, and irrigation works. It has also considered facilitating migration of farm labor to different areas during periods of peak needs. Problems created by increased unemployment through mechanization have made the Indians somewhat reluctant at times to urge an increase in use of farm machines.

It is true that mechanization often does not fit well into agricultural operations in developing countries. As noted, mechanization may displace labor and create unrest. It may be expensive to purchase, operate, and repair; therefore, it might be retained mainly for prestige purposes. It requires some skill on the part of the farmer and implies acceptance and approval of its use on the part of tradition-bound peasants who might contend that machinery use would change their way of life. For example, a machine which grinds up the straw normally needed for thatching roofs would be looked upon with disfavor, since it appears to bring about new problems rather than solve old ones.

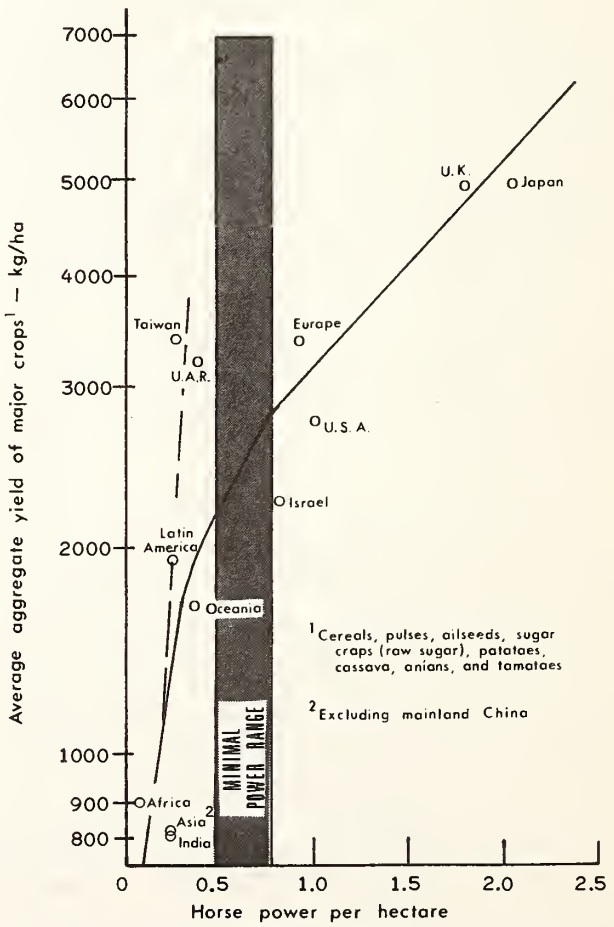
Effectiveness of mechanization may also be linked to the use of fertilizer, insecticides, and other inputs, which may not necessarily be available in the required quantities. Mechanization may not be used effectively in its environment; for example, the British Groundnut Scheme in Tanganyika failed in part because mechanized deep plowing inadvertently exposed a very poor subsoil.

Purchase of a machine may be an investment that is too large for a small holding. Large holdings often are more effective in achieving economies of operation. Nevertheless, land ownership patterns and attitudes in regard to consolidation of plots may prevent establishment of holdings that are large enough to accommodate machinery.

To a degree, there are ways to handle some of the problems mentioned above. Japan has helped pioneer in the development of small-scale machines for use on small plots; the focus here is on increased output per hectare rather than per man. In some countries, machine cooperatives have been established which perform the necessary tasks for members of the organization. In addition, it is possible to mechanize to a degree using animal power. This may be feasible and desirable in some peasant societies where complicated equipment cannot be used effectively. It can also be pointed out that, in some countries, the cost of a tractor on a per-horsepower basis may be less than that of an animal.[40]

Although mechanization may create some social, economic, and political problems, it can be helpful in increasing total production and yields. The benefits of mechanization in helping to increase yields are illustrated in figure 3-6.

Figure 3-6. RELATIONSHIP BETWEEN YIELDS IN KILOGRAMS PER HECTARE AND POWER IN HORSE POWER PER HECTARE, FOR MAJOR FOOD CROPS



Source: The World Food Problem, Volume II. A Report of the President's Science Advisory Committee. May 1967.

[40] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 400.

Machinery can be used in places where people cannot do the job; for example, tractors with steel blades can plow deeper than oxen; special seeding and fertilizing equipment is more accurate in placement and measured quantity than is hand application; the tasks of land preparation, sowing, and harvesting are speeded up; using equipment which permits uniform spraying and dusting can be more effective than a manual process; mechanical secondary tillage by plowing and harrowing also tends to result in higher yields. Mechanization becomes particularly useful in taking care of the more precise cultivation requirements of the new high-yield varieties of crops.

Since timing of operations is usually very critical in agriculture, mechanization can be helpful. If certain tasks can be performed quickly, the crop may mature before early frosts; or a new crop can be put in if the old one is damaged shortly after seeding. In India, it is estimated that for many crops there is a loss of one percent per day in yield if planting is delayed beyond an optimum period of about two weeks; in Burma, long grain paddy rice yields decrease two percent for every day that the harvest is postponed after the grain is ripe.[41]

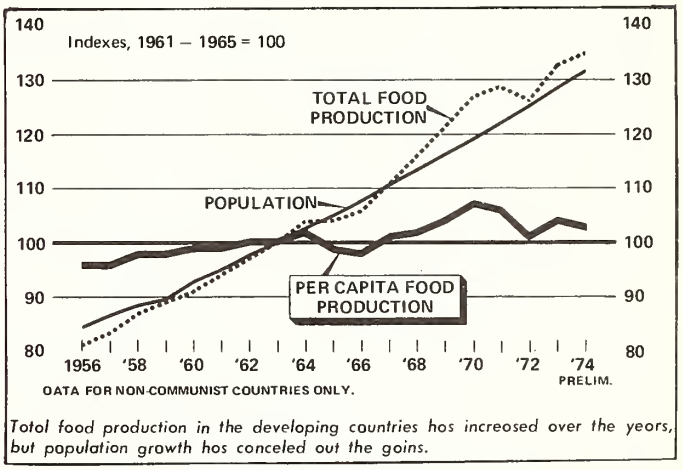
As a result of time saving and a narrower interval between harvests, it is possible in certain areas to engage in multiple cropping. Thus, even if yields are low, total production per hectare may rise. Furthermore, there apparently may be a close correlation between total labor use and multiple cropping.[42] Additional crops cultivated each year lessen underemployment and unemployment and spread the available work tasks somewhat more equitably over the seasons. During periods of peak labor requirements, machines resolve problems of labor shortage and possible loss in yields.

To conclude, a simple assumption should not be made to the effect that introduction of machinery will, under all circumstances, displace labor or result in social disorder. Furthermore, machines can often increase yields per hectare; this is no small matter in an increasingly food-short world. Finally, it is maintained that at present there is not enough total human, animal, and mechanical power per hectare in developing nations to achieve optimum needs.[43]

5.7 *Production and yields*

Agricultural production in the developing nations has increased in the past two decades. This has been a noteworthy achievement. Nevertheless, rapid population growth has minimized these gains, so that per-capita output has lost or barely kept pace with previous levels in many countries (see figure 3-7).

Figure 3-7. FOOD PRODUCTION AND POPULATION FOR DEVELOPING COUNTRIES: 1956-1974



Source: War on Hunger. U.S. Agency for International Development. December 1974.

Serious food shortages presently are threatening a number of nations. Furthermore, since food stocks have not been accumulated, any fall in production can add to this list of countries. Also, there is a possibility that economic progress in some countries may increase consumption of animal products. This, in turn, would create an additional market for feed-stuffs and thus decrease the amount of grain available in trade which could be consumed directly by humans.

[41] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, pp. 397-399.

[42] Dana G. Dalrymple. *Survey of Multiple Cropping in Less Developed Nations* (Washington, D.C.: U.S. Government Printing Office, 1971), pp. 41-42.

[43] Addeke H. Boerma. "A World Agricultural Plan," in *Food*, ed. by J. Hoff and J. Janick (San Francisco, California: W.H. Freeman & Co., 1973), p. 223.

The possibilities of increasing production and yields are discussed later. However, it should be pointed out here that the ability to increase agricultural output cannot be considered in isolation; that is, it is not merely a case of using more fertilizer, high-yield variety seeds, or of obtaining water through a newly built irrigation system. One must also consider such factors as holdings and tenure, storage and handling, transportation, markets, price structure, credit, education, and government services. The Rockefeller Brothers Foundation which made a study of the Mexican food-population gap in the 1940's, at the request of the government, came to the same conclusion. They recommended that all the problems should be attacked simultaneously. They concluded that it would be in error to focus solely on one item in the mix, whether it be technological or institutional in character.

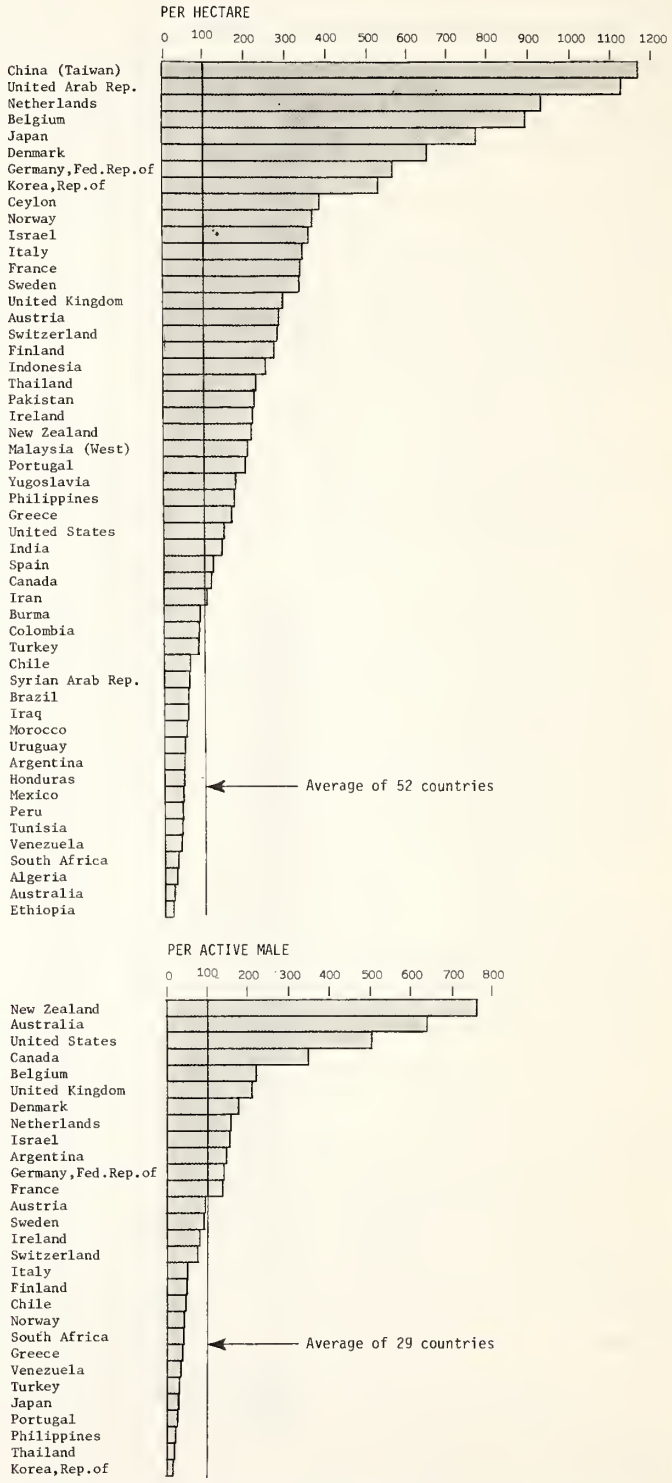
Yields can be considered in relation to land area or to farm worker. Note in figure 3-8 that many Western European countries have fairly high yields, both per worker and per hectare; this is a result of mechanization and a fairly substantial set of inputs, including fertilizer and manpower.

It has been pointed out that high yield per hectare implies an intensive type of agriculture, whereas a high yield per man involves a mechanized, extensive type or operation. The productivity of labor can be measured by computing yield, usually by crop, per working day. It is perhaps slightly misleading to measure increasing output per man on a time scale without also considering the assistance such a man is getting from outside sources. No man really feeds 75,000 chickens per day; rather, one has to consider the contribution of the people who supply machinery, feed, storage, and other inputs needed for him to feed that number.[44]

National figures on yields can be misleading. For example, Spain and Italy usually are named as the countries with the highest per hectare rice yields. Yet output is limited, and usually only the best lands suitable to rice cultivation are

Figure 3-8. GROSS AGRICULTURAL OUTPUT PER HECTARE OF AGRICULTURAL LAND AND PER ACTIVE MALE IN AGRICULTURE

(Indices, average of all countries = 100)



NOTE: Data of gross agricultural output are based on the FAO index numbers of agricultural production. They exclude feed, seed and waste, and are aggregated by using regional average producer prices relative to wheat. Data of output and agricultural area refer to the 1962-66 average but for active males in agriculture it has been necessary to use census data referring generally to 1960, 1961 or 1962.

Source: The State of Food and Agriculture 1968. Food and Agriculture Organization of the United Nations. Rome, 1968.

[44] Georg Borgstrom. *The Food and People Dilemma* (North Scituate, Massachusetts: Duxbury Press, 1973), p. 88.

used. If similar highly productive areas in Japan are compared, yields would be about the same.

An additional point should be made regarding yields. High output per hectare, such as might be found in Western Europe for certain crops, does not necessarily represent an economically sound type of agriculture. For example, farm yields in West Germany are high but generally costly so that much of the production must be financed by the government in order to remain competitive.

Finally, it is noted that recent increases in yields have occurred not only in rice and wheat, but in tea, cocoa, coconut, rubber, and oil palm production as well. While this is encouraging, it is also true that this increased capability to raise yields has generally involved production from commercial rather than subsistence agriculture.

Although increases in yields have been proportionately greater in developed nations, there has been a modest rise in output per hectare among the developing nations as well. Comparisons in world cereal area, yield, and production for 1961 and 1972 are as follows:

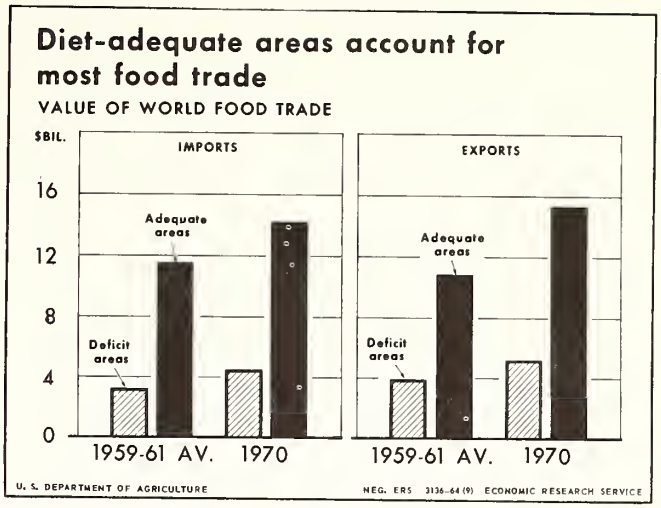
Countries	Area	Yield	Production
	Hectares (millions)	Tons per hectare	Tons (millions)
1961:			
Developed.....	147	2.1	314
Developing.....	261	1.1	278
Centrally planned.....	256	1.3	332
World total...	665	1.4	924
1972:			
Developed.....	146	3.1	452
Developing.....	290	1.3	367
Centrally planned.....	263	1.7	456
World total...	698	1.8	1,275

Source: The World Food Situation and Prospects to 1985. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 98. December 1974. (Data supplied by FAO.)

5.8 Markets and trade

The products of subsistence agriculture do not usually travel far. Most of the food trade consists of imports and exports to and from diet-adequate areas, which are generally the developed countries (see figure 3-9). About two-thirds of the grain produced in India, for example, is consumed locally. Markets are found in central places or villages that furnish goods and services to meet the modest needs of the subsistence farmer. Quality of products sold in the market is based on visual inspection. Transportation services can be relatively simple, given the comparatively short distances involved. Storage facilities are minimal.

Figure 3-9. WORLD FOOD TRADE



Source: The World Food Budget, 1970. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 19. October 1964.

The market structure for commercial agriculture is much more complicated. It involves transportation, storage, processing, and distribution. Markets may be local, regional, national, or international. Since producer and consumer may be far removed from each other, a middleman function is required. Some form of quality identification has to be substituted for visual inspection; this may require establishment of standards, specifications, grades, and labels. Governments become involved in the marketing process, since they must furnish some of the supplementary needs of the system, such as transportation facilities, public storage if necessary, market information, food quality regulation and protection, and marketing research and education. Greater emphasis probably should be placed on these matters than has been done in the past. Most agricultural development programs have tended to focus on production rather

than marketing. This is unfortunate, since marketing is just as critical a factor in developing a successful commercial agriculture as production.[45]

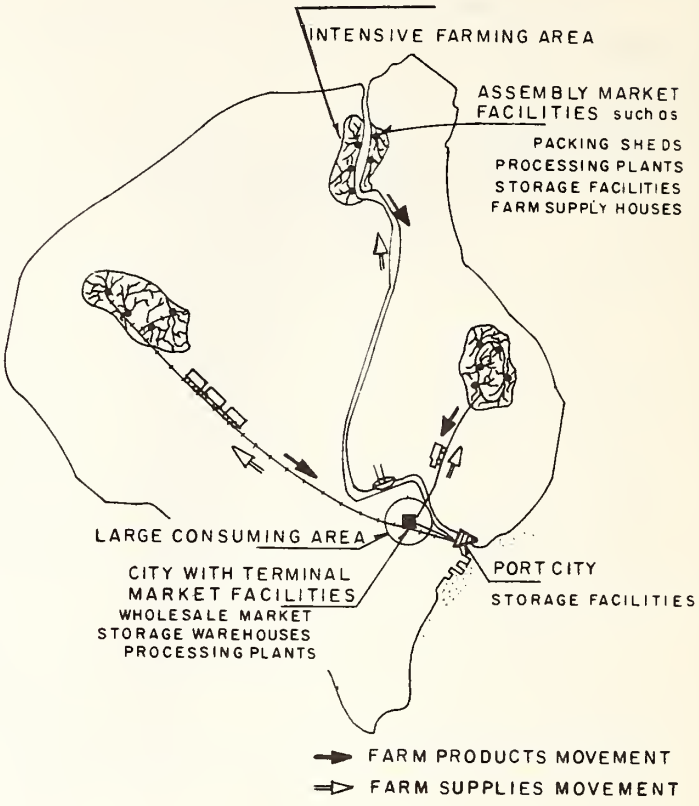
5.9 *Storage and handling*

Storage and handling facilities are required to maintain an efficient marketing chain which extends from the producer to the consumer (see figure 3-10). For the consumer, these facilities provide a sustained supply; for the producer, they help to prevent abrupt seasonal price changes that are due to the inability to store products after the harvest. In places like Africa and the Mid-East, there is a strong seasonal character to agricultural output and prices. Animals must be sold at a certain time of the year because feed is not available during the dry season. By contrast, winter feed shortages in Europe are met from the store of feed produced in the summer. In other areas, farmers may be forced to sell their crops after harvest (even though they have the capability to store it for a time) because they often are unable to obtain financial credit on the basis of stored products.

Developing countries have little capacity for food preservation and generally are poorly equipped to handle and store agricultural products. Some countries have seriously considered the establishment of a national food reserve, but this usually is very costly.[46]

Government assistance often is required to establish adequate storage and handling facilities and to integrate them into the transportation system. Such assistance does not necessarily guarantee an efficient operation. For example, some very bad weevil infestations in Africa were reported under the supervision of government agencies with poorly trained staffs.[47] Possibly community

Figure 3-10. INTEGRATION OF TRANSPORTATION WITH MARKETING AND PROCESSING



Source: The World Food Problem, Volume II. A Report of the President's Science Advisory Committee. May 1967.

efforts to build storage facilities would be helpful; but these require capital and trained personnel for purposes of supervision. Again, some form of government aid is generally required.

To do the job adequately may require advanced and costly dehydration (drying), refrigeration, and heat sterilization techniques. The most modern and efficient processing establishments in developing nations are often associated only with perishables destined for export. Lebanon, for example, can accommodate almost its entire apple crop with its cool storage capacity.

Sometimes refrigeration problems can be avoided. For example, bottled milk can be boiled, rather than pasteurized, and can then be stored for long periods at normal temperatures (until the containers are opened). This is a common procedure in parts of Spain.

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[45] M. Alexander. *Investment Policies for Projects in Agricultural Marketing.* (Washington, D.C.: Inter-American Development Bank, Papers on Agricultural Development, No. 10, 1973), p. 1.

[46] Food and Agriculture Organization. *State of Food and Agriculture, 1968* (Rome: 1968), p. 142.

[47] Ibid, p. 121.

World losses through inadequate handling and storage are extremely high. One estimate is that they amount to 110 million tons of food grain alone. Half of this amount could feed 500 million people.[48] Reliable data, however, are hard to obtain; furthermore, very little research has been done on qualitative or nutritional loss.

Losses result mainly from micro-organisms, insects, rodents, molds, fungi, and poor handling. The estimated annual grain loss in India is almost 7 percent; in Ghana, 8 to 16 percent of the maize is lost; and in Nigeria, 4 percent of the sorghum is lost.[49] Other estimates are often considerably higher. Proper storage probably could cut most losses considerably.

5.10 Cooperatives, credit, and services

Cooperatives can sometimes obtain some of the efficiencies that are available to large farm operations in matters involving mechanization, marketing, storage, transportation, and production. If large local urban centers are located far from the agricultural holdings, farmers can attract these markets if they organize as a cooperative, as has been done in Ghana, Thailand, and the Sudan. Difficulties may arise due to a lack of capital, training, and skills, or because of the common desire of many peasants to retain their freedom of action and individualism. Nevertheless, a tradition of cooperative assistance at the village level may effectively counter this attitude and still give the small farmer an opportunity to have his voice heard. Cooperation of this kind may lead to community development programs which are formulated and directed at the "grass roots" level.

An example of how effective a cooperative can be, occurred about 40 years ago when some French Canadian dairy farmers financed a study of the English cheese market. After determining the habits, acceptable price ranges for products, and desires of the English housewife, the cooperative concentrated on the production of certain cheeses intended for this market. Quantitative and qualitative controls were established, and the French Canadians eventually were able to take part of the trade away from such efficient producers as the Danes.

Credit is an important key to agricultural development. Since loans of capital on easy terms are not always possible to obtain, a cooperative can be of great assistance in providing credit. Individual farmers are otherwise often at the mercy of landlords or shopkeeper money lenders; their interest rates, due to the high risk character of the loan, may be very high. Private banks may be of limited help, since the small farmer usually has little property to offer as insurance that he can repay the loan. Accordingly, peasants often are considered to be outside the scope of operations of the commercial banking system, and their poverty continues and extends to the next generation. Government agencies often supply credit, but usually limit it to specific reform or development programs, thereby not making it available to all farmers.

Scale economies (benefits from a large-scale operation) include the cost of a loan. For example, the cost of administering a $5,000 loan to a cooperative generally is about the same as for a $50 loan to an individual.[50] Credit services of cooperatives also can result in purchase of equipment and inputs (such as fertilizer) at bulk rates, thus providing the individual farmer with goods at prices which he normally could not command.

Finally, in discussing assistance to farmers, mention should be made of an extension service. It is estimated that the developing nations require about 400,000 trained agricultural specialists for employment in such agencies. This still would represent a ratio of only one expert per 2,000 farm people.[51] By way of contrast, India and Thailand

[48] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 554.

[49] Food and Agriculture Organization. *State of Food and Agriculture, 1968* (Rome: 1968), pp. 118-119.

[50] Robert d'A. Shaw. "A Rural Employment Strategy for South America," *Focus* (March 1973), p. 6.

[51] Tadd Fisher. "The Many-Faceted Food Problem," *Population Bulletin* (December 1968), p. 94.

currently have an average of one agronomist per 33,000 farmers. The picture is not as discouraging as it might seem, particularly when one can point to the Mexican experience; that country has managed to train a sizable number of agronomists in a fairly short period of time.

Although it might be possible to spread some information by way of the transistor radio, that type of communications medium has its limitations. For example, a peasant might try a new farm technique he heard about on his radio and not be successful. Ideally, he should then be able to obtain expert aid through the extension service to examine the technique carefully and correct the failure. Without this personal assistance, he would probably conclude that the new technique is inefficient, useless, or even harmful.

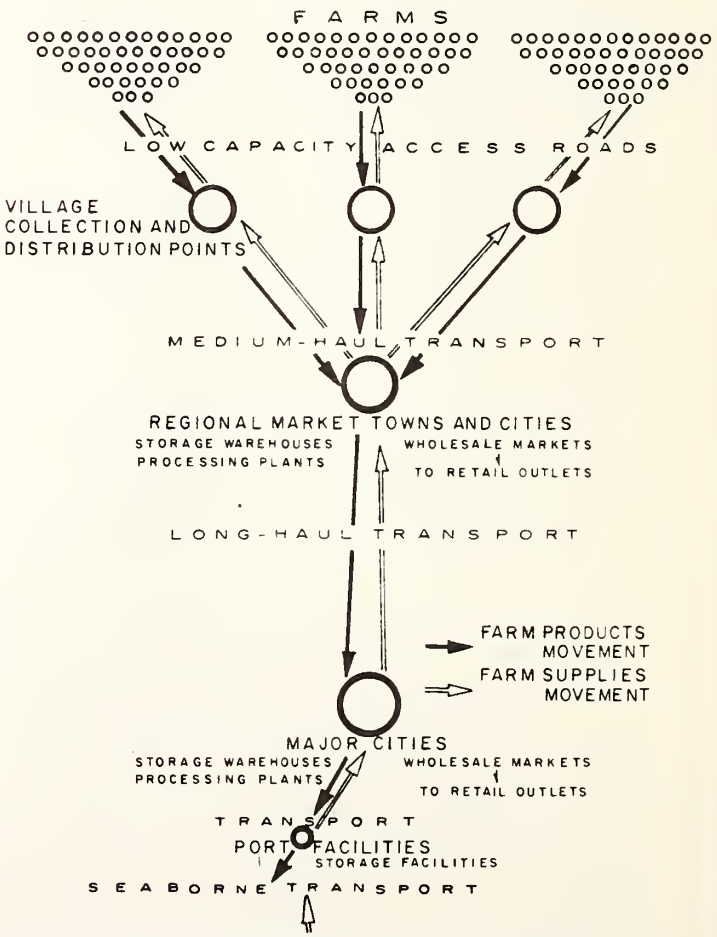
Private enterprise can and should be used to supplement the work of the extension service. Universities and research agencies might be used more effectively in this regard. Basically, however, the establishment of a well-funded, well-trained, and active extension service is essential for proper agricultural development. Some opposition may be expected from peasants. At the turn of the century in the United States, many farmers would have resisted the advice of an agronomist who was foreign to the immediate area and who possibly had never seen the farm on which he was passing judgment and giving advice. Many peasant societies resist change and would not accept advice readily, but experimental plots and demonstrations often help. For an advanced, commercial agriculture, extension service assistance is essential, at least in part because the fruits of research and development are transmitted through it to the individual farmer.

5.11 Transportation

Transportation can play a significant role in determining agricultural land use. Desirable physical qualities normally will not be enough to offset poor location of a holding. Accordingly, land-use patterns develop on the basis of both site and situation. Site often refers to the physical impact of the immediate surroundings on a place; situation refers to the influence of conditions often far removed from the immediate location. Site is sometimes compared to one's house and situation refers to the neighborhood in which one lives.

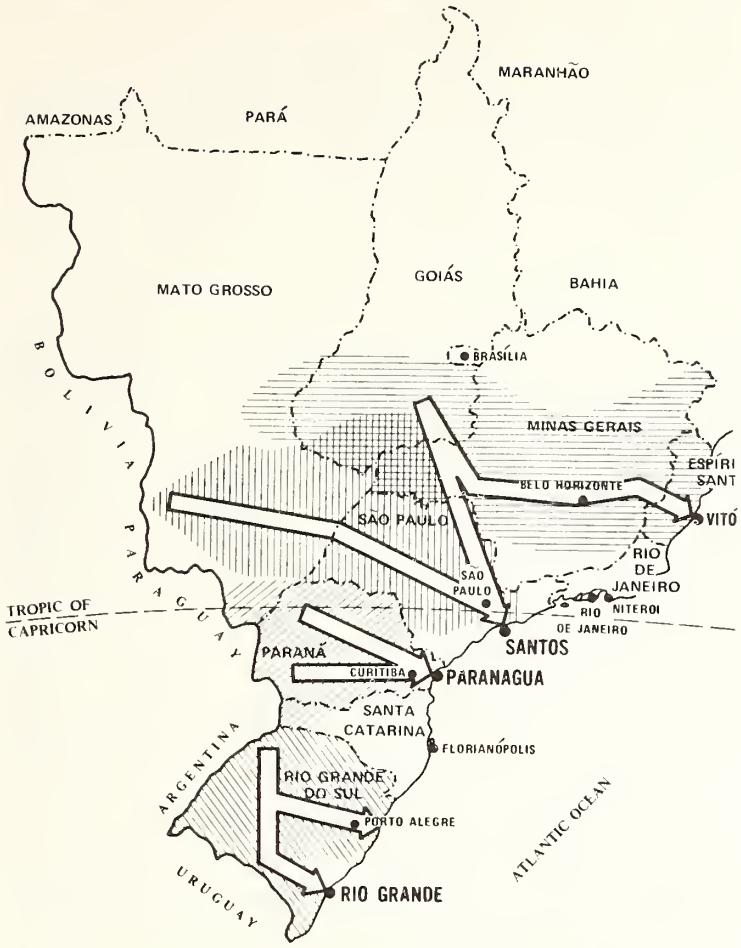
The influence of situation can be demonstrated by a simple model developed by J.H. von Thunen, a 19th Century German economist. The assumptions for this early model are a homogeneous physical environment, a commercially-oriented agriculture, only one type of transportation (with its costs proportionate to distance), and a market and producing area solely dependent upon each other. The model suggests that belts of agricultural land use would develop around the market or village. Farmers close to it would have a wide range of

Figure 3-11. ESSENTIAL ELEMENTS OF A TRANSPORTATION SYSTEM TO SERVICE AGRICULTURE



Source: The World Food Problem, Volume II. A Report of the President's Science Advisory Committee. May 1967.

Figure 3-12. BRAZIL'S EXPORT CORRIDORS



Source: Foreign Agriculture. U.S. Department of Agriculture. October 8, 1973.

products to grow for sale, whereas those farther out would have fewer choices. Those closer in probably would concentrate on perishable goods, such as fluid milk, fruits, and vegetables; while the farmers farther away would tend to grow grains under increasingly less intensive methods. The outermost ring would be used for grazing.

Although the model deals with an agricultural economy of the past and with only one cultural and political area (Germany), its value lies in its contribution of the idea that agricultural land use can be conditioned as a result of location as well as physical and cultural factors. As noted, the existence of bands of market gardens around many cities, despite differing conditions, would seem to support this idea.

It is unnecessary to emphasize that a prosperous commercial agriculture requires good transportation facilities. Vehicles and a road network are essential to supply the various inputs needed for high agricultural productivity and good quality and to carry goods to market efficiently and at low cost. This involves a fairly extensive network of low-capacity routes for each agricultural area which, in turn, is connected by high-capacity routes to larger collection and distribution centers (see figure 3-11).

It is desirable not to neglect the development of the secondary and tertiary networks, as is often done, in favor of the major routeways; neglect will only retard the commercial development of agricultural areas. How can fertilizer and insecticide, for example, be brought into an area in sufficient amounts and on time without an adequate road network? How can products, possibly perishable, be brought to market quickly without a satisfactory road network? There is little point in urging a subsistence farmer to use more fertilizer or grow more crops for market if he is located in an area which is difficult to reach. Figure 3-12 illustrates what the Brazilian government is doing to establish well-developed transportation routeways from centers of agricultural production to the market areas and ports.

Where farmers have ready access to major commercial routeways, the results often are favorable. Thus, when a program of road expansion was instituted in Mexico, the commercial production in areas served by the new or improved roads increased substantially. Generally speaking, agricultural areas in developing countries are poorly served by roads. For example, only 11 percent of all of India's 580,000 villages have reasonable access to some form of modern transportation. Similarly, it is estimated that motor vehicles in the People's Republic of China can reach only about half of the

production brigades (settlements).[52] One can grasp the great magnitude of the transportation problem if the People's Republic of China decided that it wanted to commercialize all of its agriculture. For many countries, the alternative is to focus only upon farm areas on deltas, river plains, and along some coasts, where transportation is easier.

5.12 Commodity agreements and the political factor

Governments exert varying degrees of influence over agriculture. The degree of influence is determined by such factors as the extent of political involvement of farmers; the prevailing views regarding land ownership and tenure; the desire for economic independence, government grants for agriculture, tax policies and extension services support; and the dependence on farm export trade. It is doubtless true that, "Few agricultural prices in today's world are uninfluenced by governmental policies."[53]

Economic independence is strongly advocated in many countries. This is because some nations, such as Great Britain or Switzerland, have found it most difficult to obtain food in time of war. It is also because some governments believe that the importation of food products that presumably could be grown domestically weakens the economy. They reason that income from food imports affects the balance of trade in an unfavorable manner. Generally, economists suggest that agricultural (or industrial) self-sufficiency in all countries is not desirable, but this theory is not wholly accepted for different reasons. Some nations have fixed low prices for certain farm products so that they can be exported at a profit. Others do not tax agriculture heavily, thus stimulating production from small, intensive holdings and retarding production on large, under-utilized estates. Governments at times may place ceilings (top limits) on prices of goods destined for urban markets, thus reducing the incentive for farmers to increase production. Some programs support domestic production, despite the fact that the cost of the final product is higher than the import price. This disregard for the principle of comparative advantage can become the basis for a protective agricultural policy in some nations.

Nations may also encourage or discourage mechanization, research, production controls, cooperative organization, or tariff supports. They may provide assistance in the form of guaranteed prices, deficiency payments, soil banks, direct grants, or protective duties. They can influence farmers to withdraw from the market, or encourage them to increase or decrease production. Handling of agriculture is based in part on the economic and social goals of the nation.

Despite the different attempts by many nations to control agriculture, comparatively little work has been done on an international basis to formulate agreements and establish guidelines which would help place controls over production and consumption. Commodity agreements are of fairly recent origin and generally have not been very effective. They have involved a variety of products--sugar, rubber, olive oil, wheat, and coffee. One of the most recent attempts has involved bananas. The Food and Agriculture Organization has sponsored some meetings to gain international commodity agreements dealing with rice, oilseeds, citrus fruits, fats, and fibers--agreements that are basically similar to those concerned with minerals.

It has not been easy to establish a supply structure and pricing mechanism to which all producers and consumers would agree, over an extended period. Most efforts have failed to raise or stabilize prices, or to influence production over time. Their appeal lies mainly in the idea that a unified position on the part of the producing nations can, to some extent, remove the pricing determinants for the commodity from a purely economic setting to the political scene. One might also maintain that the agreements clearly attempt

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[52] Philip W. Vetterling and James J. Wagy. "The Transportation Sector, 1950-70," in U.S. Congress, Joint Economic Committee, *People's Republic of China: An Economic Assessment* (Washington, D.C.: U.S. Government Printing Office, 1972), p. 162.

[53] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, p. 71.

to raise prices by limiting output. Nevertheless, they are a kind of device to which the developing nations may turn increasingly, if it is felt that the produers, as in petroleum, can control the market. It is not always clear, however, whether such attempts will succeed. There seems to be little evidence in the past to indicate they could succeed.

5.13 Attitudes

Attitudes in regard to production and consumption vary. Peasant socieites, with differing value systems, may not equate high yields and output with their social and economic goals. It has been noted that many--although certainly not all--farmers will not grow more food than they feel they need. Moreover, some traditional farmers may view new ideas with suspicion. Thus, if peasants do not trust the authorities, they will not easily believe that the yields on their own land will match those of demonstration plots. (In the United States, for example, it took almost two decades for farmers to accept hybrid seed corn.) Yet it is true that new high-yield varieties of rice and wheat have been introduced successfully. Probably, part of the answer lies in the attempts to take local customs and conditions into consideration in introducing new farming techniques. Very often, the acceptance of new methods requires a basic change in a way of life. It is for this reason that many nomad people have resisted change to agriculture in a settled community.

Consumption habits also vary widely and may be difficult to change. This too can have a direct effect on production. Muslims do not eat pork and Hindus do not eat beef. Chinese and certain East Africans do not like to drink milk. Intake of other foods may be forbidden or restricted during certain periods of the year. Again, production is directly influenced and conditioned by such customs. Nevertheless, some habits and beliefs are subject to change. People who prefer rice as a dietary staple have been persuaded to accept wheat as a supplement. However, this takes a carefully planned program of consumer education and time. Incaparina, a high-protein food supplement, has been marketed in Latin America without notable success, although the sales program has been clever and appealing. It is not easy to change lifetime habits quickly.

In dealing with attitudes, one final point should be made in regard to the image of agriculture. There is often a tendency for students to reject agricultural education because farming is considered a lowly occupation and an undesirable way of life. Despite this, more (rather than less) talent is needed in agriculture, in order to help close the population-food gap. It should come as no surprise that many farm people themselves hold similar views regarding the low status of agriculture; this helps to act as a stimulus for migration to the urban slums.

6. INDUSTRIAL LOCATION FACTORS

Industry occupies little space and is not spread evenly over the landscape. Generally it is located in and around urban centers of varying sizes, either in the central city or suburbs or in satellite towns or other places within the city region. Exceptions to this rule are few. Certain industries may be found close to a source of minerals or associated with a perishable product. For example, processing of copper ore, which is often of low grade, would not be profitable if the raw material were moved a great distance; this would account for the location of the Chuquicamata copper operations in Chile. Similarly, sugar refineries are located near the producing fields, since the harvested product loses its sugar content quickly. In spite of the advantages of nearness to the source, industrial establishments are generally clustered together in close association with urban regions.

Industrial location factors should help explain the clustering pattern. Some of these factors have greater application than others, depending on the industry. Usually it is a combination of features which influences the location pattern. A number of these are briefly described below.

(1) Certain industries are raw-material oriented. Nevertheless, there appears to be a trend away from this conditioner of location, particularly in modern industry. Hong Kong and Japan can serve as examples of places with industrial centers which are poorly located in relation to proximity to many raw materials.

(2) Some industries are market-oriented, particularly those that deal with perishable goods, high-style products, and goods which gain in bulk in the manufacturing process. This would apply to fluid milk, but not to hard cheese. It also would help explain the location of beer and soft drink factories and auto assembly plants.

(3) The physical factor may have some significance. Areas with a high percentage of slope would turn industry away; areas with favorable climates, by contrast, might tend to attract industry.

(4) Transportation and accessibility can be very influential; certain mountainous areas and basins tend to be isolated and therefore harder and costlier to develop.

(5) An area that has a history of industrial activities often retains some of its industrial mix, even though new regions arise to compete with it.

(6) Clustering of industry itself can be important. For example, the Italian government has not been very successful in moving industry from the northern manufacturing regions to the poor agricultural south. Industries that are alike tend to cluster, since they can achieve external economies of scale by means of cheaper per unit transportation costs for raw materials and for finished products. Furthermore, certain industries can serve a number of others that are engaged in related manufacturing processes; also, women can be employed in light industry located near heavy industry operations.

(7) The political factor may be significant. Industrial development agencies can help bring manufacturers into an area by offering such incentives as tax benefits, training of personnel at government expense, or provision for low-cost utilities. Government intervention also can serve to scatter industry, to a small degree. For example, the pricing of energy so that the costs are artificially declared to be the same throughout an electrical grid network would scatter large power users rather than cluster them near the site of a dam.

(8) Availability of energy and energy costs may be very significant, particularly for some industries.

(9) The labor force factor can be very influential in some cases. Generally, modern industry requires skilled personnel. Some highly automated establishments, such as those producing textiles, also can employ semi-skilled personnel; however, the number of semi-skilled employees is usually not large. Certain industries actually may locate close to skilled labor, rather than vice versa. This is true in computer manufacturing, for example.

(10) All other things being equal, comforts and conveniences may become important. In other words, some attention would be paid to housing, and to educational, recreational, political, and cultural considerations.

(11) Finally, a large corporate structure may permit a certain freedom in terms of location of individual plants.

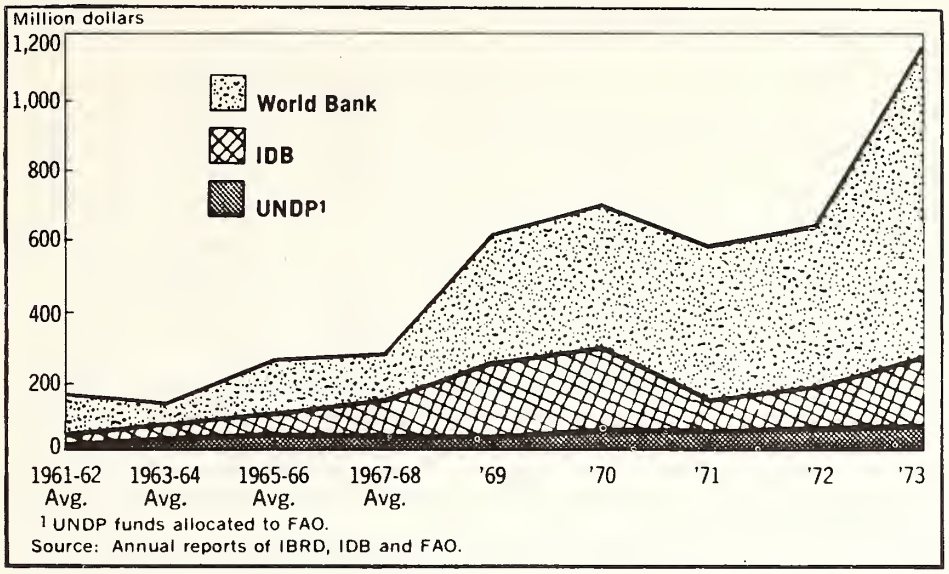
In view of the foregoing considerations, it would appear as though the ability to bring modern industry into rural areas is limited. For the most part, it would be limited to city regions and, to a small degree, to some fairly isolated urban centers.

A number of countries have attempted to scatter industrial operations into the countryside. The People's Republic of China, for example, has encouraged small-scale operations because it is trying to establish some degree of regional economic independence. This policy is partly motivated by the poor transportation system which exists in most areas. The program has not been particularly successful. Establishment of labor intensive handicraft and cottage industries in developing countries has also met with little success.[54]

Some individuals and agencies are urging that a modest attempt at rural industrialization should take place, even though earlier efforts have not been too rewarding. The Inter-American Development

[54] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 182.

Figure 3-13. FUNDING OF AGRICULTURAL PROJECTS BY MULTILATERAL ASSISTANCE ORGANIZATIONS



Source: Foreign Agriculture. U.S. Department of Agriculture. October 28, 1974.

Bank has shown some interest in supporting such undertakings. Two points should be made regarding such industrialization: (a) as has been emphasized earlier, only certain areas possess favorable location factors, and (b) a substantial input is needed in the way of credit availability, provision for utilities, market studies, managerial and employer training, development of transportation facilities, and the like. With such assistance, the probability of success is increased.

7. AGRICULTURAL DEVELOPMENT PROGRAMS

Agricultural development can take various forms. It may involve an organized and systematic effort on the part of government or international agencies (see figure 3-13), or it may be a spontaneous development in which no formal planning was considered. The amount of capital, knowledge, and effort can vary greatly; it may involve simple improvement of range land or a large scale colonization and irrigation project. Development also can take the form of agrarian reform.

7.1 Organized versus spontaneous efforts

Organized development involves a major planning effort and capital input on the part of a government. The results can be impressive. For example, the Venezuelan government in a comparatively short time settled 165,000 new farm families, distributed 4.5 million hectares of land, irrigated 60,000 hectares, built 10,000 kilometers of new roads, improved 18,000 kilometers of old roads, doubled the electrification of homes, made low-cost fertilizer and seed available, and set up a system of farm grants and supports. The costs for such a program are high. Similarly, Mexico has expanded its road and rail network, developed new productive crops from domestic sources, encouraged farm mechanization, and trained a group of skilled agronomists to help improve the agricultural segment of the economy. These were significant achievements.

In some cases, expenditures are substantially higher than in others due to the type of costs that result from road building, new housing, electrification, sanitation, certain technical assistance, construction of educational facilities, or supplying various types of farm inputs to settlers. There may be difference of opinion regarding the degree of support necessary. One view is that the costs of some forms of assistance are much too high and that the increased output from the area is not sufficient to cover the basic expenditures. On the other hand, if little is done to provide assistance and conveniences for the settler, there is the danger that he may simply become a subsistence farmer and help to spread the rural slum. For example, a road may be built through a segment of the frontier and settlers may be given the right to claim the land in what is still a fairly inaccessible area. Since there is little possibility that these somewhat isolated farmers will develop a commercialized agriculture, the farmers may camp and live on the road.

Spontaneous development involves settlement of new lands with little official assistance or control. Costs are thus minimal for the government.

In a few cases, subsistence farmers may be able to sell more products off their new farms than they had in their previous locations. In most cases, however, little thought is given to the market. Furthermore, practically no assistance is rendered to help farmers improve the quality of their livestock or crops or to increase production generally. It is hard to imagine peasant farmers able to provide the capital inputs they need to increase yields. Such farmers often may be skilled agriculturalists, in terms of the things with which they have to work, but this does not convert them into commercial farmers.

Theoretically, then, agricultural development probably should be attempted through a systems approach, or an improvement plan in which all of the factors which influence the program are considered and weighed. Planners should consider several factors.

Initially, a good data base is required to assist in the analysis of cost effectiveness. It is disappointing to note that large sums of money may be spent constructing some dams, for example, without good knowledge of such important factors as area labor skills, underemployment characteristics, market potential, and soil yield capabilities. A cost-benefit study should be made which can help provide planners with information regarding alternative development programs that they might wish to consider.

Attention also should be paid to a number of the subjects discussed in this and earlier chapters: holdings, tenure practices, mechanization, inputs, markets, storage, cooperative organization, credit, transportation, comforts and conveniences, physical characteristics, pollution, environmental management, urbanization, industrialization, and education. There is a feeling prevalent among some analysts that decision-makers should attempt to see the development process as a whole, and resist the temptation to look for simple solutions which focus on only one factor.[55] Indeed, if all of the factors noted above interact cooperatively, the total result is usually greater than the sum of the parts.

If success in agricultural development is based essentially on the satisfaction of a whole range of costly conditions, then the future prospects for countries with limited means would appear to be discouraging. For many countries, this need not be the case. Modest improvements, at the very least, are always possible.

Perhaps an effort should be made to concentrate on programs with good potentials, rather than spreading available resources thinly. Governments should not expect that simple solutions can be obtained solely by means of technical innovations. A national policy which concentrates on supported industrial development and continuing protectionism, and which neglects a workable agricultural base, is self-defeating and counterproductive.

Finally, an effort should be made to integrate rural development planning and population control programs. The major thrust in family planning up to now has been directed toward the cities. This is understandable; funds, staff, and facilities are limited and transportation in rural areas often is difficult. Yet, it may be unwise to neglect the rural countryside in this regard since, in many cases, the effectiveness of agricultural planning often is counterbalanced by rapid rural population growth. Moreover, urban growth is directly affected by migration from overpopulated rural areas.

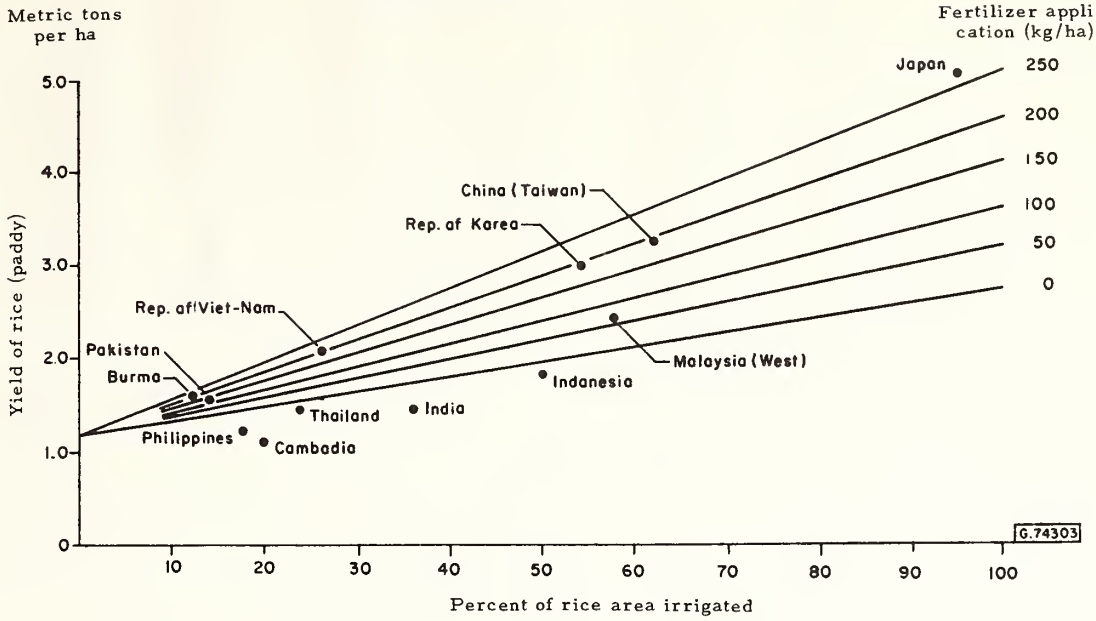
In large measure, the race in the immediate future is not so much one between food and people as it is between what can be done and what will be done.

7.2 Irrigation

About 11 percent of the cultivated land area of the world is irrigated, but produces only about 10 percent of the total food output. (Many irrigated areas have poor growing conditions.) There is not a balanced distribution among all countries, however, and the imbalance is made greater by the fact that the developing countries, which have

[55] U.S. Department of Agriculture. *The World Food Budget, 1970* (Washington, D.C.: U.S. Government Printing Office, 1964), p. 65.
Quentin M. West. *World Food Needs* (Washington, D.C.: U.S. Government Printing Office, 1966), p. 8.
President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, pp. 85-86.

Figure 3-14. RELATION BETWEEN RICE YIELD PER HECTARE AND PERCENT OF RICE AREA IRRIGATED (Average 1959/60-1963/64)



Source: International Rice Research Institute, Annual Report 1966. Los Baños, Philippines, 1966.

two-thirds of the world's population, have less than half of the world's arable land. Yet, those same developing countries contain three-quarters of all irrigated land. About one-third of all the rice land in Asia, for example, is irrigated.

Water use in large irrigated areas is controlled by irrigation societies (such as in Java), by government agencies (as in the Gezira, Sudan), or by a combination of both (as in the Guadiana River Basin in Spain). The costs of irrigation can be very high. For example, hydroelectric power generation encourages the maintenance of a high level of water in reservoirs, whereas flood control necessitates a drawing down of water levels. This requires that a series of dams, rather than one, be built to compensate for such differing goals. Furthermore, the dams and attendant features are fairly costly structures, and they tie up a considerable amount of capital for long periods of time. Then years may pass before some financial returns on the investment become evident. The World Bank thus argues strongly that irrigation should be considered only if it is economically justifiable.[56]

Allocation of costs in multipurpose projects often is arbitrary, but it seems fairly clear that some areas are more expensive to irrigate than others. For example, costs in Kenya are about four times as high as the costs in the Sudan.[57] Despite such differences, the advantages seem clear--labor intensive agriculture, high yields, multiple cropping possibilities, and insurance against drought. Figure 3-14 shows the relationship between yields and extent of irrigated area. (It should be kept in mind that quality of seed, fertilizer, and other inputs also affects yield.)

For all its benefits, irrigation creates some problems. Some of these have been referred to before: salinization and waterlogging of soils, high cost of development, and ecological disruption. As with agricultural development generally, it is not enough to bring the water to the land. The other ingredients previously mentioned must also be considered. For example, farmers must be trained in order to operate their holdings efficiently. They must be taught something about the correct timing for water application, the desired amount and depth of watering, and the different

[56] International Bank for Reconstruction and Development. *The Economic Development of Spain* (Baltimore, Maryland: Johns Hopkins Press, 1963), p. 277.

[57] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 435.

irrigation techniques required for various soils and crops. Irrigators also must learn how to adjust to the needs of their neighbors. Since water use is rationed, a fair amount of cooperation is necessary. Another problem is a legal and administrative one. Water controls established in one part of a river system might affect other parts, since the basin is one physical unit. Yet, the area may be politically divided. Problems of this kind have arisen many times; for example, consider the difficulties of water management of the Indus River basin between India and Pakistan.

The potential for irrigation in some areas is good. Perhaps more attention should be paid to productive humid areas with good possibilities for increasing output, rather than on glamorous projects to make the deserts bloom. The total productive area in South America could probably be doubled; that in Africa could be tripled. In parts of Asia, the area that is eligible for development is also sizable. The water might come not only from river basins but from large subsurface sources as well. To substitute for more expensive forms of irrigation, some attempt probably could be made to increase the use of portable pumps and tubewells (irrigation wells enclosed in tubes). On the whole, however, the cost to prepare land for intensive farm use will be fairly high.

7.3 Agrarian reform

Agricultural problems in many countries commonly result from the imbalance of holdings and ownership. It is true that in some countries a small number of land owners control most of the farm land, and a large number of farmers with tiny plots own a small proportion of the land. However, it has been pointed out that, because of low carrying capacity, large ranches are not necessarily inefficient. Furthermore, large well-run holdings can achieve certain economies of scale; if subdivided, production usually falls. These conditions suggest that assistance might often be extended more profitably to the large farm than to the small one, if increased production is the objective. The political and social influence in regard to land ownership is a strong one and must also be considered, along with the purely economic objective to maximize farm output.

Population growth creates another problem. In Latin America, new families outnumber, by about 20 to 1, those families receiving land from the government. In India, the number of people with plots of less than 2 hectares is so great that the division of all holdings over 8 hectares would add an extremely small amount to the average size of these small farms.

The point has been made previously that solutions to agricultural problems should be viewed by considering a broad range of related matters. To focus solely on land distribution, no matter how inequitable it may be, confuses the objective. The argument here is not against land reform itself but rather its political use as a suggested solution without taking account of other factors. The Director General of the Food and Agriculture Organization points out that this type of reform must be linked to a wide range of measures which raise productivity.[58]

Agrarian reform (the subdivision of holdings) is not a program that can be easily accepted in some countries. It implies drastic revisions of the existing social, economic, and political structure in many cases. If the inequities of land ownership are unacceptable, it may be equally unacceptable to suggest that division of holdings will improve production or necessarily provide a plot of land for each farmer who wants one. In those few cases where good, accessible land is available, the demand for agrarian reform is not normally a very strong one.

8. AGRICULTURAL REGIONS AND TYPES

Agricultural regions can be classified in a variety of ways. Some of the criteria which can be used are as follows: crop and livestock combinations and degree of specialization; level of intensity of operations; tools and methods used;

[58] Addeke H. Boerma. "A World Agricultural Plan," in *Food*, ed. by J. Hoff and J. Janick (San Francisco, California: W.H. Freeman & Co., 1973), p. 224.

degree of commercialization; social and ownership features; scale of enterprise; and climate. Each of these criteria, individually or in combination, however, do not categorize all agricultural areas in a completely satisfactory manner.

8.1 Primitive and subsistence crops and livestock

Primitive agriculture supports a very small population, yet covers a very large land area. On a sliding scale, it is the least commercialized when compared to some forms of subsistence agriculture that may involve a substantial amount of trade off the farm.

Shifting cultivation, in which the land rather than the crop is rotated, is known by many names. Some of the more common terms are swidden and slash-burn. It is practiced in Central America, the Amazon Basin, sub-Saharan Africa, and South and Southeast Asia; it represents a particular way of life to the people. Some farmers in these cultures have strongly resisted government attempts to settle them in permanent villages in valley bottoms. Crops vary by area, but the rotation system is common to all. Fields are burned and cleared and then cultivated for a year or two. The burning provides the soil temporarily with a few selective plant nutrients. Since there is no land pressure, farmers do not return to the field for a period of 10 to 30 years. Thus, the soil usually is able to recover, and the natural vegetation is allowed to take over again. Swidden farmers often are fairly skillful and knowledgeable agriculturalists, considering the inputs available to them.

Nomadic herding is in some ways a livestock parallel to shifting cultivation. It is found along the desert margins of Africa and Asia and in the subarctic areas of North America and Eurasia. It also involves a small population and a large land area. Since the nomad is very dependent on his animals for his livelihood, available forage governs his movements. Under certain conditions, however, some nomads can become settled farmers and they temporarily cultivate land around an oasis for a short period of time before moving on. Clan boundaries may not be clear, but access to water is more critical since survival may depend on it. In some areas, seasonal rainfall may provide pasturage; such desirable land might also become a source of friction between clans. Widespread drought, however, may unify the tribes and result in an out-movement of these peoples into outlying areas. This partly explains the periodic movement of Kurds, Tartars, and Mongols into China, South Asia, and Eastern Europe.

Subsistence farmers may be involved in intensive or extensive operations. The types of crops they grow are quite diverse, and the areas in which they live are widespread. The degree of commercialism in their farming also varies. Accordingly, there are many sub-classifications.

Large numbers of people are involved, particularly in Asia, and animals play only a minor role. No crop is dominant, although rice and corn are common in the humid areas; and wheat, sorghums, and millet are prevalent in the drier regions. Oilseeds are grown for internal farm consumption and for sale. Cotton is usually featured as a commercial crop. In some cases, with sufficient rainfall and growing period, multiple cropping is possible. Under favorable conditions, multiple cropping can be attempted even in an area with a wet-dry seasonal change. In India and Pakistan, for example, the kharif crops are grown during the rainy period and the more drought resistant rabi crops are grown during the dry season.

8.2 Mixed farming

There are two major types of mixed farming. The first resembles subsistence farming in that not all crops are sold off the farm. Generally, field crops and horticulture predominate, and livestock plays a minor part.

Mixed farming is found mainly around the Mediterranean basin and in central Chile, where the growing season coincides with the dry season. This creates a problem, which is solved partly by irrigation in some areas. There are other regions of the world with similar climates, such as Cali-

fornia in the United States, but a different type of agriculture is practiced there due to the influences of such factors as location, accessibility, and markets.

Dry farming, involving fallow plowing or the growing of legumes to help maintain soil moisture, is common. Animals are used for a variety of purposes and hardy native breeds of low productivity predominate. Fodder often is difficult to obtain and many areas have been overgrazed and suffer from the effects of accelerated erosion. The Mediterranean basin, particularly, is noted for high quality Merino sheep which are seasonally shifted from highland to lowland areas.

The second type of mixed farming is more advanced and involves close integration of crop and livestock production. It is found in the eastern half of the United States; in Europe from Northern Spain to the Ukraine, and on to Lake Baykal in the Soviet Union; in Southeastern Brazil; parts of South Africa; and a segment of New Zealand. In the United States, a large proportion of the crop output is converted into livestock products and the operations are highly mechanized. The Corn Belt is part of this area. In Europe, the concentration is on cereal production, particularly wheat, for direct human consumption. Cattle and hogs in both regions usually are high grade, selectively bred types. In Brazil, cereal cultivation and livestock are found in conjunction with more specialized types of farming such as coffee, sugar cane, and cotton holdings. The proportion of pasture land there is higher than in the United States and Western Europe.

8.3 Specialized agriculture

The agricultural types grouped in this category are varied. The major characteristic is the tendency to concentrate on production of a limited and specialized nature.

8.31 Commercial grain farming.--Commercial grain farming is found in the North Central United States and contiguous parts of Canada, in Eastern Europe, and in the Ukraine and Kazakhstan in the Soviet Union. Livestock production is often associated with grain farming--for example, in the wheat belts of the Argentine Pampas and in southeastern and southwestern Australia.

A high degree of mechanization is common and holdings are very large. Other crops alternate with wheat and seldom make up a monoculture (growing of only one crop). Cereals such as rye, oats, barley, corn, and sorghums, usually are grown in rotation.

8.32 Paddy farming.--Paddy or sawah farming is associated with rice culture and irrigated areas. It is found in Eastern India, Bangladesh, Southeast Asia, the Philippines, Indonesia, Mainland China, Japan, and Korea. Paddy rice cultivation may be almost monocultural in some of these areas, and multiple cropping (that is, growing a crop two or more times a year) can be common. Rice is well adjusted to the monsoon climate that prevails over the region, but some other crops (such as wheat or vegetables) also may be grown, depending on the areas involved.

Paddy farming is a very successful form of agriculture that requires good social and administrative organization and skillful water management. In some places paddies have been constructed on slopes by means of terracing. Figure 3-15 (on the opposite page) is a picture of rice terraces in the mountains of Luzon in the Philippines. They are among the best built and most extensive in the world.

Paddy holdings are usually small, but yields are sizable. Paddy farming is also labor intensive; one analyst estimates that 1 hectare requires 313 man-days per year and can feed 12 people.[59] The cost of keeping animals is high since pasture land and fodder are limited; fish cultivation, however, is common. Paddy farming is highly commercialized in such areas as Southeast Asia and Japan.

In addition to paddy farming, there are many other types of irrigated agriculture throughout the world. They are commonly associated with areas

[59] Leslie Symons. *Agricultural Geography* (New York: Praeger Publishers, Inc., 1967), p. 85.

Figure 3-15. PANORAMIC VIEW OF RICE TERRACES IN THE PHILIPPINES

Source: Foreign Agriculture. U.S. Department of Agriculture. August 13, 1973.

in which arid and semi-arid climates prevail, but they may be found under humid conditions as well. In the case of the humid regions, however, irrigated zones are not as extensive in area, and water control is not as rigorous.

8.33 Irrigated cropping.--Growing a crop more than once in one year is common on irrigated land in warm climates, and animals usually have a secondary role. Generally, holdings are only moderate in size, but they may be highly commercialized. Some examples of this type of agriculture are to be found along the western sides of the Andes in Peru, in Egypt, in southern Iraq, and in the Imperial Valley in northwestern Mexico.

8.34 Plantations.--On occasion, some observers classify plantations as a specialized type of agriculture.[60] Although quite different in many ways, they have several characteristics in common with other specializations.

(1) Plantations (large farms with plants under cultivation) have historically represented a foreign form of agriculture in the Asian, Latin American, and African countries in which they are located. In recent times, however, plantation operations have been increasingly integrated into the local economy and social structure.

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[60]David Grigg. "The Agricultural Regions of the World: Review and Reflections," *Economic Geography* (April 1969), pp. 126-127.

(2) Their high degree of specialization, commercial orientation, size of holdings, and capital investment distinguish plantations from neighboring agricultural types.

(3) Small-scale native farmers recently have been increasingly successful in competing with crops from plantations; as examples, one can mention bananas from Ecuador, cacao from Ghana, coffee from Ethiopia, and rubber from Malaysia. Sumatra, Java, west Malaysia, Ceylon, Assam, and Central America still have large numbers of plantations, although the area they cover is small in comparison to their economic significance.

8.35 Horticulture.--Horticulture is associated largely with urban areas, since these places provide good markets for fresh fruits and vegetables. This type of farming is capital intensive in some countries and labor intensive in others. With increased capabilities in refrigeration, transportation, freezing, and quick canning techniques, horticulture areas have tended to become less market oriented and have concentrated in regions with more desirable climates. The farming is intensive. For example, multiple cropping linked to livestock production in the Hong Kong area can absorb about 2,000 man-days of labor per hectare and provide for a net cash income of U.S. $2,000. In some urban centers with high-income suburban populations, this type of farming also would include nurseries and greenhouses. One of the major problems for urban agriculture in recent times has been pollution, which can cause serious crop damage.

8.36 Dairying.--Dairying can be found in association with urban agriculture or mixed farming, or as a separate specialization. It may be capital intensive and highly mechanized to the point that feed is brought into the barn and the animals are not usually taken out to pasture. On the other hand, it may simply represent a secondary form of farm income in which capital requirements are minimal. Around large urban centers, perishable fluid milk usually is involved. By contrast, butter, cheese, and condensed milk production may be far removed from major markets. Generally, the best areas for dairying have humid, cool climates, such as are associated with the Eastern and Central United States, the North Sea area, Australia, and New Zealand. Farms generally are moderate in size and, in some cases, pig production may be closely associated with the dairy operations. Production of fluid milk in a number of Latin American countries has increased within recent years. Improvements also have been made in the quality of the product as dairies have established grades and insisted on production controls.

8.37 Commercial grazing.--Commercial grazing generally is associated with the semi-arid prairie or steppe grasslands of the world. It is to be found in the eastern half of Brazil; in Argentina, Uruguay, and Paraguay; in the regions of the Chaco, Pampas, and Patagonia; in the llanos of Venezuela; in South Africa; in the western half of the United States and adjoining parts of Canada; and in the eastern, western, and northern segments of Australia. Holdings are large, the carrying capacity of this type of area is moderate to poor, and the land is generally unimproved. Capital investment per worker often is high. Sheep and cattle are primarily the livestock involved, although goats may be grazed in some of the poorer areas. The tropical savannas are less desirable as a whole because of a higher incidence of animal diseases and because the grasses usually are not as nutritious as those in the mid-latitudes. Furthermore, poor transportation facilities usually require long and difficult trips for the animals in order to reach a railroad or market. This results in a substantial loss of weight. In Argentina, commercial grazing and crop production often are closely linked; on the other hand, in southern Brazil and Uruguay, where there is sufficient rainfall, there is no such integration of activities.

8.38 Other animal specialization.--There are some other types of animal specialization which might be noted. Fish cultivation has been mentioned in connection with paddy farming. In addition, mechanized egg and poultry production and the raising of animals for their furs might be mentioned. These operations do not take up large areas; as specializations, they are found mainly in the developed nations.

9. SUMMARY

Agriculture often is considered, by nature, to be subordinate to other sectors of the economy. If this view is held, there is sometimes a danger that agriculture will receive little support from the government, and that income from agriculture will be used mainly to encourage other national economic ventures. This may prove to be self-defeating, considering the danger of an unfavorable balance in the food-population ratio.

Several characteristics of agriculture should be emphasized. First, size of holding should not always be equated with productivity. Some holdings may be truly under-utilized. Others (in semi-arid areas, for example) must remain large in order to achieve economies of scale. Second, while tenure is not necessarily a bad practice, conditions of tenure should be examined. Third, use of fertilizer is limited in many areas--not because it is unavailable but because transportation is inadequate. It also appears that some elementary training in fertilizer use is necessary. Fourth, introduction of machinery into an area does not always lead to a decrease in the need for labor. Acceptance of mechanization is facilitated if an attempt is made to tie its use to local needs and customs. Fifth, market studies are necessary for successful agricultural development. Sixth, land-use patterns are influenced by location, as well as by physical and non-physical factors. The concentration of market-garden or horticultural rings around cities seem to prove this point. Locational factors also are significant in considering where to set up agricultural processing establishments. In general, these establishments are associated with city regions. Finally, agricultural development depends upon a variety of factors; it is not realistic to assume that eliminating one obstacle or concentrating on one improvement can resolve all the problems and increase productivity.

Chapter 4. POPULATION-FOOD BALANCE

1. INTRODUCTION

The relationship between population and resources is not always clear. Several methods have been developed to measure the effect of one on the other, but generally they have not proved to be practical. The resource concept itself is not a clear one, and this has also hindered attempts to refine the relationship.

Regardless of the way in which population and resources (specifically, population and food supply) can be measured, a major effort will have to be made to increase agricultural production in order to fight famine and malnutrition. Indeed, two of the basic objectives of the United Nations Food and Agriculture Organization's Indicative World Plan are to increase cereal production and to introduce variety and improve the quality of the diet of peoples in developing countries. This chapter focuses not only on population balance measures, but also on the possibilities for increasing world food supplies.

2. RESOURCE CONCEPTS

The term "resource" refers to something which man recognizes as being useful. For example, the Chinese of Shansi Province were long aware of coal in the subsurface of the area before they learned that it could be burned as fuel. The coal was not a resource until people learned how to use it. Similar examples can be found in agriculture. The first settlers in the prairie lands of the United States settled along stream valleys where soils were not particularly rich. There were several reasons for choosing these locations, but one factor was a lack of recognition of the high fertility of the surrounding prairie soil.

Some observers interpret the term "resource" very broadly and include not only physical and cultural features but people as well. The term "resource" as used in this chapter does not include "human resources."

Ideas concerning the definition of the word "resource" are often closely linked to economic considerations and the existing level of technology. In the 19th Century, agricultural machinery, windmills, and the railroad helped to change the Argentine Pampas from an extensively used grazing area into one of the world's leading surplus producers of meat and grain. Up to that point, this basically rich area was not used and not considered worth developing.

Since man determines whether something is or is not a resource, it follows that differences in perception, cultural attitudes, or economic motives will affect the way in which it is used. Thus, some people are more successful than others in developing areas with few resources. However, possession of a rich resource does not necessarily benefit the people in the area in which it is found, regardless of their perceptions or abilities. For example, the coal mined in Appalachia in the United States brought the country great wealth and industrial power, but the people in the region, including the miners, have not especially benefited from it. The point, however, should not be overstated. A region which can be easily reached and which has good soils and climate, for example, has an advantage for cultivation which others do not. All things being equal, such areas make up the rich agricultural regions of the world.

A number of judgments are involved in determining the value of resources. The renewable or non-renewable aspects, available technology, intensity of use, amount of waste, managerial capabilities, and institutional attitudes are all factors which must be considered. Some of these are

difficult to evaluate, but they must be examined if any serious attempt to measure the balance between resources and people is to be made.

3. *DENSITY MEASURES AND OPTIMUM POPULATION*

A number of density measures have been developed and used to measure population pressure. Some of these are discussed below.

Much has been written on "optimum" population even though the idea is difficult to understand and is not easy to quantify (determine the quantity). Despite the fact that few analysts are satisfied with the various ways to assess population pressure, the thought remains that a good method of comparing population and resources must be developed. There is continuing need for a good method. As one observer put it, in commenting on optimum population, the fact "that one cannot decide on a figure does not make the question an unreal one."[61] The concept of "optimum" remains and various measures are used because, despite their deficiencies, they are useful tools and no one has discovered or created anything better.

3.1 Theories of optimum population

Theories of optimum population can be approached in several ways. They can concern themselves with economic, social, political, ecological, or psychological criteria, or with combinations of these. People from varying cultures and countries might also view the concept subjectively and differently. What an Indian might accept as an optimum, a Nigerian might not, since their individual views of the needs and quality of life might vary.

Interpretation of the idea of "optimum" is subjective (that is, influenced by judgment rather than facts). People with different training and motives will sometimes develop conflicting definitions of the term "optimum." What a military leader might desire as an optimum, a social reformer might not. One can also see the interpretations which might be made by businessmen, nationalists, medical experts, biologists, demographers, agronomists, wildlife experts, economists, ecologists, and defenders of zero economic growth.

The time factor might be important in developing a good definition. What may appear to be in balance at one time may not be at another. For example, during the depression of the 1930's, a number of advanced countries in Western Europe felt what appeared to be population pressure. Yet 30 years later they were so short of manpower that labor was imported from other nations. It might be argued that a short-term rate of unemployment alone is not necessarily a true measure of over-population. Whatever the point of view, however, it should be remembered that the definition of over-population can change within any society or group of people over a period of time.

Some observers consider a country over-populated if it relies on imported resources--specifically food.[62] Others simply consider the various kinds of costs and problems involved in importing goods.[63]

Optimum concepts must also consider population qualities. What is optimum could be affected by such factors as age and sex distribution, labor force characteristics, or education and income levels. Cultural attitudes and customs might also influence what is considered optimum. Under certain conditions, population pressure has led to greater efforts to produce more and to live better. Although this is not true of all peoples, nor would it be possible in many cases, it does highlight the influence of the human element.

Thus there are many optimums, based on different value systems and individual and societal goals. These optimums, however, all represent

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[61] G.R. Taylor. "Optimum Populations," in *The World's Population*, ed. by Q. Stanford (New York: Oxford University Press, 1972), p. 191.

[62] Georg Borgstrom. *The Food and People Dilemma* (North Scituate, Massachusetts: Duxbury Press, 1973), pp. 51-52.

[63] Edward A. Ackerman. "Population and Natural Resources," in *The Study of Population*, ed. by P.M. Hauser and O.D. Duncan (Chicago, Illinois: University of Chicago Press, 1959), p. 622.

some sort of balance between resource availability, needs, and use, in order to provide a desired life style.

The determination of what is optimum is not an end in itself but is a means by which observers can determine the extent of a population-resource problem. It might be argued that instead of using so much effort to determine an optimum, planners should focus on the question of the optimum rate of growth and how it can be used. It does not appear, however, that such a rate can be quantified any more easily than a calculation which does not change.

One geographer has defined an agricultural balance in these terms: it is the "maximum number of people a given area will maintain under a given system of usage without land degredation setting in."[64] This definition does not consider the desires of people for a better life, for increased productivity, and higher living standards. One African geographer claims that optimum population or population pressure concepts should consider three, rather than two, variables--not only resources and people, but also expectations.[65] Unfortunately, expectations are hard to define and measure.

There have been a number of attempts to determine how much agricultural over-population exists in some countries. Some studies have arbitrarily selected a certain net income per family or minimum hectares per farm to use as a guideline. The size of the surplus population is then determined on the basis of published agricultural data.[66] Other observers have selected certain criteria which they feel can indicate the degree of over-population, such as man-hours worked versus those required, by type of farm and crop; comparisons with neighboring countries; extent of outmigration; density data; patterns of ownership and operation of farms.[67] Despite these efforts, attempts at defining optimum population have met with little success. Many observers can often agree with vague and general theoretical notions regarding an optimum, but not with its quantification or specific aspects.

3.2 Density measures and their uses

If the objective of density measurement is to compare the relationship of people to resources, then the measures currently used have only limited value. Some are so generalized as to be meaningless, whereas others have value only if they are applied to areas of limited extent and with small populations. One of the major failings of most of these measures is that they equate people and land area but do not consider the differences in the resources of different areas. Mineral wealth, for example, should not be measured solely in relation to the size of the area in which it is found, but also in terms of its quantity, quality, and accessibility. Thus, a true man-resource balance should not focus only on land area in relation to people.

3.21 Arithmetic density.--The arithmetic density is referred to and used more often than any other type of measure. Sometimes known as the man-land ratio, or crude density, it compares population to area. Since it does not consider the different qualities of the population nor the different qualities of the area, it can be a particularly misleading statistic; yet its use is widespread. The reason is probably the same as that which accounts for the continuing attempts to measure optimum population; that is, the man-land ratio is relatively easy to calculate and, despite its failings, appears to provide a general guide to determine population pressure.

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[64] John M. Street. "An Evaluation of the Concept of Carrying Capacity," *Professional Geographer* (March 1969), p. 1.

[65] Akin L. Mabogunje. "A Typology of Population Pressure on Resources in West Africa," in *Geography and A Crowding World*, ed. by W. Zelinsky, L. Kosinski, and R.M. Prothero (New York: Oxford University Press, 1970), p. 118.

[66] Robert E. Dickinson. *The Population Problem of Southern Italy* (Syracuse, New York: Syracuse University Press, 1955), pp. 90-91.
J. Tomasevich. *Peasants, Politics, and Economic Change in Yugoslavia* (Stanford, California: Stanford University Press, 1955), p. 311.

[67] Samuel Baum. *Population, Manpower and Economic Development of Eastern Europe* (Washington, D.C.: George Washington University Publication, 1961), pp. 7-8.
W. Zelinsky, L. Kosinski, and R.M. Prothero. *Geography and A Crowding World* (New York: Oxford University Press, 1970), passim.
John M. Hunter. "Population Pressure in a Part of the West African Savanna: A Study of Nangodi, Northeast Ghana," *Annals of the Association of American Geographers* (March 1967), passim.

The leader of the Third Reich in Germany once defended his policy of Lebensraum by pointing out that Germany had the highest crude population density rate in the world; whereas many other countries, such as Bolivia, were quite empty and had very low densities. Yet, even at that time (in the 1930's), the level of living was unquestionably higher in Germany than in Bolivia. Similarly, the crude density of the United Kingdom is about 1 1/2 times that of India; this fact, by itself, does not necessarily indicate a higher level of living in the less dense country.

Further examination reveals that level of living in many countries is not correlated with population density. Some industrialized and advanced nations, such as Belgium and Japan, have high ratios; whereas others, such as Sweden and New Zealand, have low ratios. Some developing countries, such as Laos and Kenya, have low densities; others, such as Bangladesh and South Korea, have high densities. Moreover, crude density does not suggest whether there is greater population pressure felt at the upper or the lower end of the economic scale. To put it another way, the pressure in a country with a high density figure, such as Taiwan, might be less acute than it is for Mozambique, which has a much lower density. The pattern is the same for areas of smaller size, such as cities. For example, living standards in large urban centers may be much higher than poor rural areas despite a very great difference in density.

A further failing of arithmetic density is that, if it is used as a national average, it fails to reflect regional differences. For example, the average crude density for Indonesia does not reflect the high concentration of people in Java and the sparse settlement pattern in Sumatra; for the United States, it does not reveal the congestion in parts of Megalopolis and the relative emptiness of the desert in Nevada; for Egypt, it does not show the great differences between irrigated and unirrigated areas. This helps point out the fact that not all land areas and carrying capacities are alike. One square kilometer in the center of Calcutta is not used in the same way as one square kilometer in the middle of the Sahara Desert. Such a simple conclusion seems obvious, yet users of crude density figures apparently consider the two places to be very much alike, since the land areas used are not weighted or differentiated from each other. In similar fashion, the populations are also not differentiated in any way in this measure. Thus, the skilled workers producing computer machinery in Sao Paulo (Brazil), for example, are not in any way classified differently from unskilled aborigines in Amazonia.

It would be very desirable for data producers and consumers to develop and use crude density figures with great caution. Researchers who use these calculations and apparently obtain revealing conclusions from them might, with equally defensible logic, conclude that cows and goats are exactly alike since they are all ruminant (cloven-hoofed and cud-chewing) mammals. Conclusions drawn from using arithmetic densities can be victims of the lack of logic. Thus, all people are considered exactly alike, presumably because they are human; presumably all land areas are exactly alike since they contain some form and mixture of earth materials. People often have a tendency to use arithmetic density because "it is there."

3.22 Urban density.--The urban density measure is calculated exactly like crude density, but is applied only to urban areas. It is not usually intended to be used directly as a measure of the population-resource balance, but is sometimes used by planners and other researchers in studying transportation, housing, urban growth, market patterns, and market problems, and in making comparisons between the central city and the suburbs. Urban density is not always correlated with income, since wealthy areas with high-rent elevator structures or prosperous single dwelling residential structures may have higher or lower densities, respectively, than the slums.

Statistics similar to those of urban density are sometimes gathered by using housing units as a base. For example, calculations can be made to indicate the number of persons per housing unit or persons per room. The latter figure presents problems since the size of the rooms is usually

not taken into account. Rooms in slums are often smaller than those in wealthy areas; therefore the housing space available per person is not an accurate figure. Similar situations also exist in rural housing in various countries. Sometimes "persons per room" is referred to as crowding, rather than density.[68]

3.23 Physiological density.--Physiological density, sometimes also known as nutritional density, compares population with arable land. Since the population inputs are not specific, only broad generalizations can be deduced. It has already been pointed out that the definition of arable land differs from country to country and that the quality of what is considered arable may also vary greatly. Definitional problems are involved in what is considered fallow, forest, pasture land, and crop land. For example, consider the estimate of 0.71 hectares of arable land per person in agriculture in Brazil. People who believe that tropical areas are (or can be made) fertile, might disagree with the definition of what type of land is declared arable.

Furthermore, physiological density does not consider the effect of inputs such as fertilizers, which can affect productivity but are not used equally by all countries. India uses 11 kilograms of fertilizer per hectare of arable land, whereas Japan uses 405.[69] Physiological density also does not consider accessibility, which might be an important factor in making food available to the major market centers of the country. Finally, this measure does not indicate the impact of international trade which permits some countries to exchange their manufactured goods for agricultural products and vice versa.

It might be possible to weight arable land figures using some sort of value system. In all probability, this would be a more effective measure to use within countries since comparisons between countries, as noted above, often present methodological problems. Apparently, however, some analysts question the use of weights because the wide differences in land quality, even within countries, do not easily permit any statistical adjustment.[70]

The figures available for physiological density do not always disclose very much. While the density for Great Britain would be high, even a casual observer must be aware that the country relies on importing much of its food. Although some densities might indicate a great dependence on trade, they probably do not provide as useful a tool as do trade statistics.

Consider the value of the following figures in making international comparisons (the data are in terms of arable hectares per capita): Great Britain, 0.12; Chile, 0.81; Tanganyika, 1.3. Which country is the most developed? Which seems to have the greatest pressure? Are arable definitions the same? Are population skills and purchasing power similar? What uses can be made of these types of calculations? Perhaps some revealing comparisons can be made of countries which are very similar to one another and which are located in the same region, such as East Africa or Western Europe. As yet, however, it does not appear that such calculations will impart any new knowledge involving population pressure.

A similar measure that is sometimes used is a comparison of caloric intake per capita (total calories, proteins, carbohydrates, or fats). The reliability of such data is usually poor, however, and the nutritional needs of different peoples and areas are not always well-known. Such a measure is concerned with food consumption (or production) per capita and does not directly compare people with land, arable or otherwise.

Some analysts like to calculate the carrying capacity of the land. Actually, they are using a form of physiographic density. One economist estimates that under certain circumstances, a person could be fed from the continuous cultivation

[68] Population Council. *World Population Status Report 1974* (New York: Population Council, 1974), p. 33.

[69] Food and Agriculture Organization. *Production Yearbook, 1971* (Rome: 1972), p. 204.

[70] J. Kumar. *Population and Land in World Agriculture* (Berkeley, California: University of California Press, 1973), p. 101.

of 27 square meters of land.[71] He also points out that under certain conditions the world could support 47 billion people at American standards or 157 billion at Japanese standards.[72] The United Nations Food and Agriculture Organization estimates that the world could support 36 billion persons, 100 years in the future, if deserts could be irrigated and intensive farming of the entire Amazon Basin were possible.[73] Calculations of this kind have by now become fairly commonplace. These are only highly theoretical arithmetic exercises. The world is not able at present to support such large populations, given mankind's current cultural, economic, and political organization of society. Whether it will be able to do so in the future is not at all certain.

3.24 Agricultural density.--The agricultural density measure compares the agricultural population with arable area. Since it attempts to refine the population figure, it should be welcomed as a somewhat more refined measure of the relationship of people to resources. However, what is included in the agricultural population can vary. It might include full- and part-time workers or just the economically active males in agriculture; it might include persons by type of tenure, landless workers, or other similar subcategories. Again, certain things needed for evaluation (such as skills, training, or age) are often missing. Furthermore, it does not necessarily follow that a high density figure is closely related to population or land pressure. For example, Chile has less than half the agricultural density of Colombia, yet both countries have experienced rural unrest presumably as a result of land pressure. In contrast, Canada and Niger have low ratios; Canada has basically no problem of population pressure whereas Niger does have a problem in the Sahel. High agricultural densities for a few Western European countries may show some land pressure; but in determining the effect of this kind of pressure one must also give consideration to the large production and occasional surpluses of the region. However, agricultural density can sometimes be used as an effective tool for analysis if the farming is primitive and does not cover large areas.[74]

It is not necessary to mention again the difficulties involved in using arable land data to calculate agricultural density. Although this measure may have some limited value, it should be used with caution.

3.25 Felt pressure and crowding.--A subjective evaluation is involved in attempting to assess the impact of population pressure. Felt pressure has different levels of acceptance in different societies. It has been noted that what might be considered as over-population by one culture might not be so regarded by another. Accordingly, people will react in different ways to this problem. Density measures do not take this cultural factor or reaction into consideration; it is recognized that it would be difficult to do so.

There is little information available on the levels of crowding at which people work and adjust most efficiently. Study seems to indicate that some national or cultural traits can be identified in response to crowding, but they are still vague and often arrived at quite subjectively.[75] Henry Thoreau, a 19th Century American essayist, once wrote, "I would rather sit on a pumpkin and have it all to myself, than be crowded on a velvet cushion." Certainly, there might be both pumpkin and cushion sitters within one type of nation or culture. The subject seems to call for further investigation. There are some who believe that social and psychological unrest are not necessarily the result of high density conditions.[76]

3.26 Economic density.--This ratio compares people and resources, both in terms of quantity and quality. It is concerned with the standard of

[71] Colin Clark. *Population Growth and Land Use* (New York: Macmillan Co., 1967), pp. 156-157.
[72] Ibid, p. 153.
[73] William M. Denevan. "Development and the Imminent Demise of the Amazon Rain Forest," *The Professional Geographer* (May 1973), p. 130.
[74] John M. Hunter. "Population Pressure in a Part of the West African Savanna: A Study of Nangodi, Northeast Ghana," *Annals of the Association of American Geographers* (March 1967), passim.
[75] Edward T. Hall. *The Hidden Dimension* (London: Bodley Head, Ltd., 1966), passim.
[76] Population Council. *World Population Status Report 1974* (New York: Population Council, 1974), p. 33.

living which a particular population wishes to achieve and is therefore arrived at subjectively. It also attempts to determine the manner in which social and political institutions view the resource base. Economic density, in addition, tries to determine whether technological and scientific abilities are such that they can make efficient use of resources, and whether administrative policies and programs in this regard are wasteful or economical. Economic density determines the impact of trade, considers population characteristics, concerns itself with value systems, and takes account of changing resource concepts. As a result, economic density becomes very difficult to measure. It may be noted that land is no longer one of the two major items used to calculate the measure.

It has been suggested that the density measures previously described have limited utility at best. Economic density, however, is harder to determine and its failings are many. As noted, it cannot be quantified easily and it is hard to use and interpret. Nevertheless, although it may be difficult to utilize, it at least helps fulfill a need felt by many who wish to have available some measure of population balance or lack of balance. Often, only the limits are suggested in dealing with economic density. An area is thus commonly referred to simply as being under-populated or over-populated.

4. FOOD SUPPLY

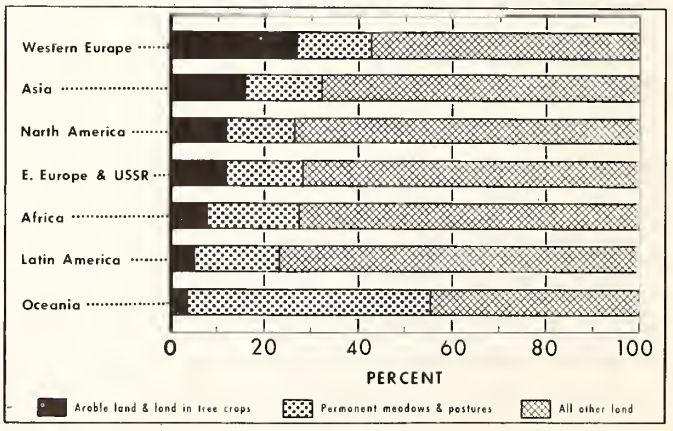
Agriculturists interested in improving the population-resource balance must try to answer the question of what realistic possibilities exist for improving farm production and productivity. They must consider the possibilities of increased output by means of higher yields, multiple cropping, and the opening of new lands for agriculture. They should analyze the results and study the lessons to be learned from the Green Revolution. They should assess the possibility of increasing the ocean catch and producing new types of synthetic foods. They must also, in contrast to the possibilities, determine the actual nutritional needs of the growing world population.

4.1 Yields versus frontiers

The problem of increasing agricultural production revolves around several potential sources of output--increased yields, development of frontiers and unused areas, the oceans, and new types of food. Efforts should be made to lessen the food-population gap by all of these means. The controversy over yields versus frontiers should not be discussed in such a way that only one possible solution is considered. Nevertheless, because funds and available skills are limited, and because different areas have different potentials, some countries will probably have to assign development priorities which focus on one rather than on both alternatives.

4.11 Extension of agricultural land.--As might be anticipated, there is some variation in the amount of land that is available for agricultural use throughout the world. The distribution is shown in figure 4-1. The proportions are approximate, since the definition of terms is applied differently in various countries.

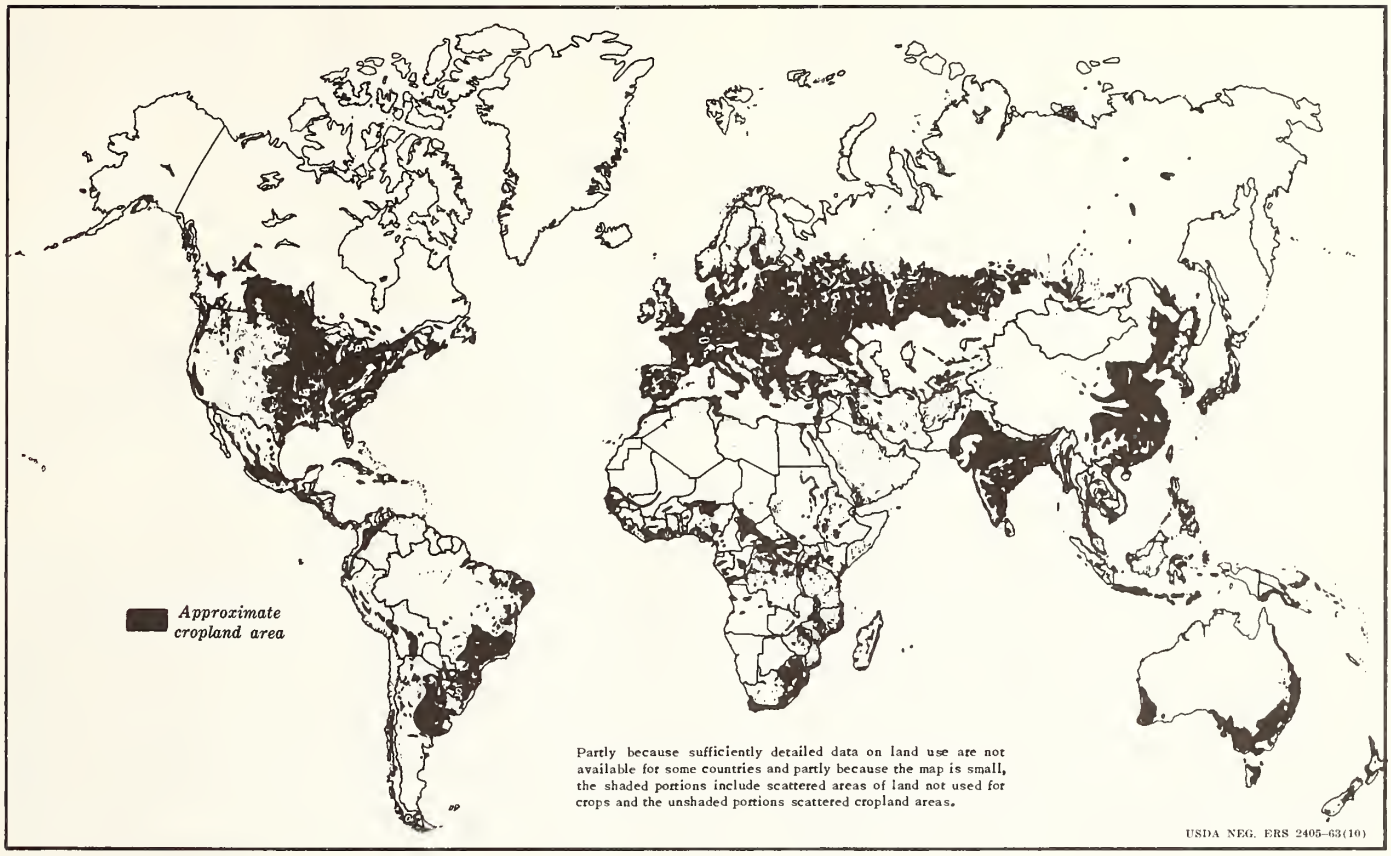
Figure 4-1. LAND-USE PATTERN BY REGION: 1969



Source: Man, Land, and Food. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 11. November 1963.

There are three basic problems affecting the determination of land use: (a) the definition of what is arable or useful; (b) the cost and accessibility factor; and (c) socio-political considerations and attitudes. If these are kept in mind, some of the estimates are not actually as different as they first might seem to be. For example, a number of analysts believe that the possibility of expanding the arable area in Asia is very

Figure 4-2. APPROXIMATE CROPLAND AREA OF THE WORLD
(Arable, including fallow, tree and bush crops)



Source: A Graphic Summary of World Agriculture. U.S. Department of Agriculture. 1964.

limited.[77] Yet, according to Gunnar Myrdal, the Swedish economist, the possibilities even for India are "by no means negligible if methods other than traditional ones are used."[78] Since Myrdal's statement suggests the need for huge inputs of capital and skills which are not now available or likely to be soon available in the required amounts, the two different views expressed above are in substantial agreement. Similarly, some observers feel that Africa and Latin America, with fairly extensive empty areas, are still not prime regions for expansion; others do not agree. Yet there is basic accord on both sides. This is because there is no real dispute as to the existence of some unused arable land. The argument instead revolves around the limiting economic and social factors and the inaccessibility of some of these areas.

The Director General of the United Nations Food and Agriculture Organization, reflecting the organization's opinion in its Indicative World Plan (the main source of agricultural policy for the UN strategy for the Second Development Decade, 1970-80), states that "better utilization of existing arable land is likely to prove more immediately rewarding in those regions than large-scale opening up of new land."[79] It is true that the developing nations have expanded grain area substantially--from 218 million hectares in the period 1948-1952 to 294 million hectares in the period 1966-1970. Much of this new land, however, may have been either marginal or costly to develop; nevertheless, the amount of available new land to be developed is becoming less and less.

[77] U.S. Department of Agriculture. *Changes in Agriculture in 26 Developing Nations* (Washington, D.C.: U.S. Government Printing Office, 1965) p. v.
Lester R. Brown. *Increasing World Food Output* (Washington, D.C.: U.S. Government Printing Office, 1965), p. 4.
United Nations, ECAFE. *Economic Survey of Asia and the Far East, 1964*, p. 106, as quoted in Gunnar Myrdal, *Asian Drama*, p. 1261.

[78] Gunnar Myrdal. *Asian Drama* (Harmondsworth, Middlesex, England: Penguin Books, 1968), p. 1265.

[79] Addeke H. Boerma. "A World Agricultural Plan," in *Food*, ed. by J. Hoff and J. Janick (San Francisco, California: W.H. Freeman & Co., 1973), p. 222.

The point has been made that varied and costly support is needed for effective agricultural development. One study estimates that an expenditure of $28 billion per year would be needed to open new lands to take care of population increases.[80] Thus, the calculation that the world has almost 3.25 billion hectares of potentially arable land[81] must take into account the cost factor. In this regard, one source suggests that new lands are generally no longer available for development at reasonable costs.[82]

Approximate cropland areas of the world are shown in figure 4-2. As the map indicates, there are large land areas that are not now cultivated. However, there is some serious question as to how much could eventually be farmed, considering investment costs and anticipated technology.

Little more needs to be added to what has already been said in regard to the non-technological problems involved in opening up new areas or in extending arable lands. Thus, although governments and public opinion may favor this expansion, major migrations into new areas have usually not taken place and frontier development is not sizable. This may reflect a general inability to support a continued effort to convert large areas for commercial agricultural use. One analyst suggests that land expansion normally cannot affect more than a small percentage of the farmers who need assistance.[83]

Expansion of agriculture into marginal lands usually requires the use of advanced techniques which can help farming to adapt to such undesirable physical conditions as aridity, or cold. For example, attempts may be made to drain or irrigate land or to improve specific plant varieties, obtain greater response to fertilizer use, or develop early maturing crops.

One of the major difficulties involved in expansion into new areas is the transfer of a plant or of a system of farming from one environment and culture to another. A crop may not adapt well to the new climate or soil and may have little resistance to native types of insects and diseases. An imported system of farming may also conflict with local customs and habits. Livestock which are accustomed to certain conditions, as noted earlier, may not transfer easily either. Rangeland in the tropics, for example, may not be as useful or desirable for high-yield animals as for native breeds. Finally, ecological problems may arise when a new type of animal or plant is introduced into an area.

In view of the foregoing, optimistic claims about the agricultural capabilities for certain areas of the world must be examined cautiously. The tropics, for example, may indeed be one of the great untapped agricultural areas in the world; but the potential, considering the physical and cultural barriers and current technological levels, is yet to be determined. New plant varieties and new methods of fertilization, pest and disease control, soil conditioning, and water management must be found and adapted to different societies in order to ensure success. This is a slow and uncertain process.

There is some evidence that increasing yields may often be a more effective agent in meeting agricultural needs than opening new lands. Certainly, the rise in farm productivity from the same land areas in some countries in the past three decades has been remarkable. Between 1948 and 1966, cultivated area in developed countries remained about the same, but yields rose about 40 percent.[84] In reality, the addition of fertilizer and other inputs and new developments in plant genetics can be considered the equivalent of opening up new lands. By contrast, cultivated area in developing nations increased by about 34 percent, but yields rose only 20 percent in the same period, as noted above. Some

[80] P.R. Ehrlich and A.H. Ehrlich. *Population, Resources, Environment* (San Francisco, California: W.H. Freeman & Co., 1970), p. 92.
[81] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 434.
[82] U.S. Department of Agriculture. *The World Food Budget, 1970* (Washington, D.C.: U.S. Government Printing Office, 1964), p. 47.
[83] Robert d'A. Shaw. "A Rural Employment Strategy for South America," *Focus* (March 1973), p. 2.
[84] Addeke H. Boerma. "A World Agricultural Plan," in *Food*, ed. by J. Hoff and J. Janick (San Francisco, California: W.H. Freeman & Co., 1973), p. 221.

differences in this regard are evident within the developing nations, however. The crop area in India has been increasing at a decreasing rate; the new crop area is either costly irrigated land or is marginal land in which yields are lower than average. In Taiwan, on the other hand, area in rice has declined in the past few years, but productivity has risen slightly. As a result of these factors, only 30 percent of increased world production is expected from new lands, whereas 70 percent is expected from higher yields.[85] Developing countries, however, might experience a somewhat different pattern of increase since there are great differences among these nations.

4.12 Increasing yields.--The possibility of expansion of agricultural land is good for some countries and poor for others. Nevertheless, most countries can hope to obtain higher yields in those areas where farming now takes place. The problems are many and varied. However, modern agriculture must be willing to accept change if yields are to increase.

Some analysts question the ability of the world to raise yields to the degree needed, assuming the present rate of population growth.[86] They note specifically the very great problems that subsistence farmers have met in trying to raise their productivity. Observers can point to the success of the Green Revolution, in this regard, but its impact has mainly been felt by the commercial farmer rather than the peasant.

Again, all of the factors mentioned in the section on agricultural development must be considered in raising yields: holdings, tenure, inputs, transportation, markets, training, services, etc. Figures 4-3A to 4-3D show the relationship between crop yields and literacy or income; they reflect the skills and inputs available to the farmer in the developed nation, as compared with his fellow agriculturalist in the developing world.

[85] U.S. Department of Agriculture. *The World Food Budget, 1970* (Washington, D.C.: U.S. Government Printing Office, 1964), p. 48.

[86] P.F.M. McLaughlin. "Increasing Agricultural Output to Help with the Population 'Problem'," in *Geography and A Crowding World*, ed. by W. Zelinsky, L. Kosinski, and R.M. Prothero (New York: Oxford University Press, 1970), pp. 86-87.

Figure 4-3A. INCOME LEVELS AND CHANGES IN RICE YIELDS

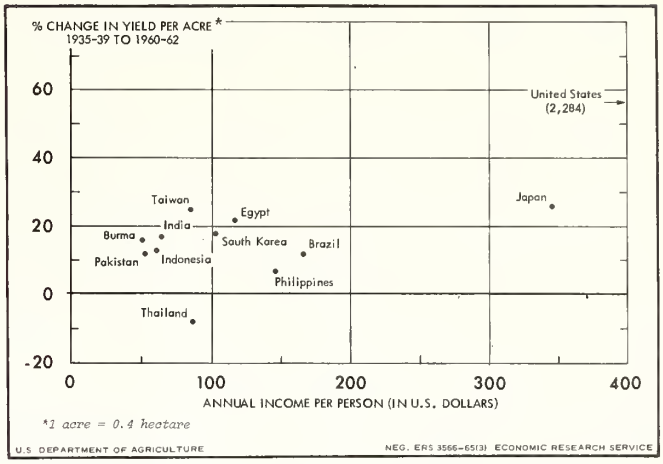


Figure 4-3B. INCOME LEVELS AND CHANGES IN WHEAT YIELDS

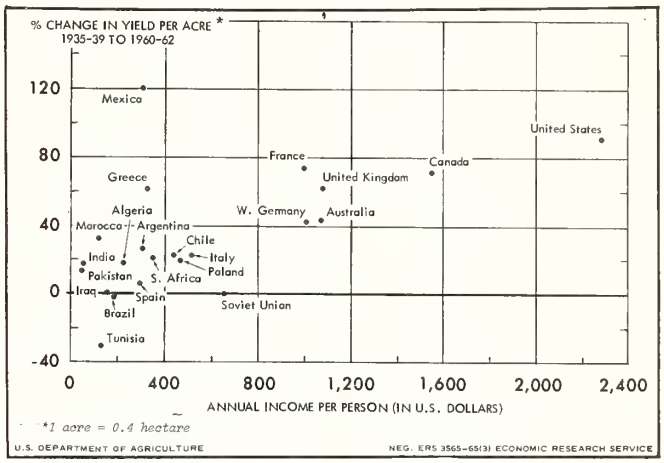
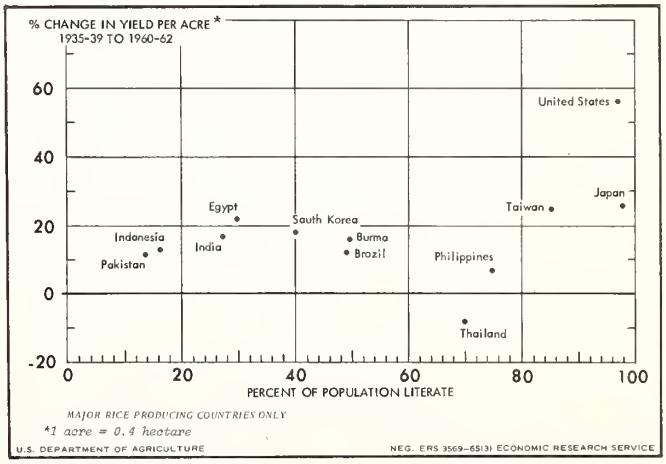
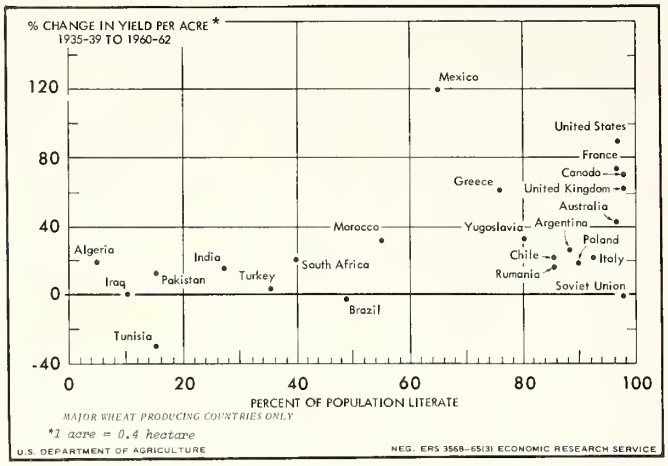


Figure 4-3C. LITERACY LEVELS AND CHANGES IN RICE YIELDS



Source: Increasing World Food Output. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 25. April 1965.

Figure 4-3D. LITERACY LEVELS AND CHANGES IN WHEAT YIELDS



Source: Increasing World Food Output. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 25. April 1965.

Implied here is a production stimulus as well. That is, output in the final analysis depends upon the decisions and actions of the farmer who may take action as a result of cultural influence, government policy, costs or prices. Essentially, reference is made to commercial operators and those subsistence farmers who regularly sell crops and animals off the farm. There is no clear evidence that a price rise can increase productivity among peasants. Subsistence farmers have to be at what one analyst calls the "yield-takeoff" stage in order to be motivated by market considerations.[87] This, in turn, would necessarily require a higher level of living, a market orientation, diffusion of new techniques, and the development of the non-agricultural sector.[88] Getting the subsistence farmer to this point is a slow process and there is no assurance of success.

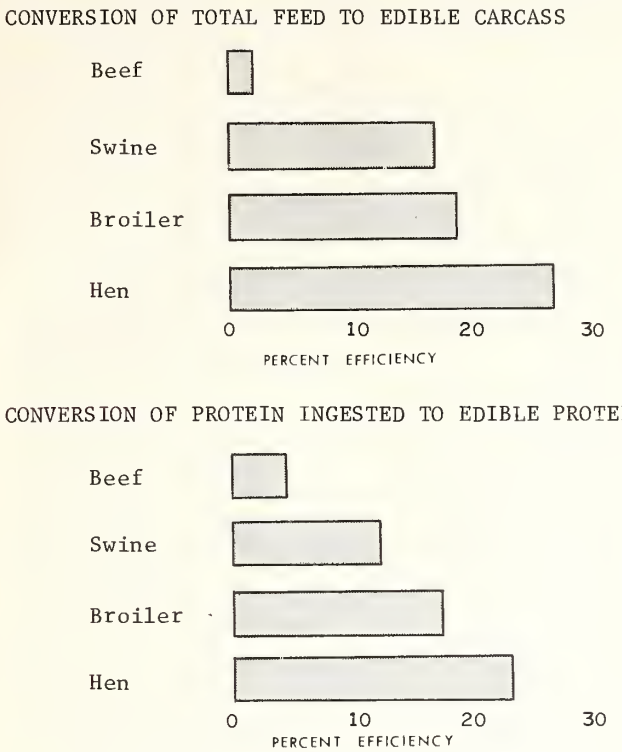
Basically, economic demand rather than need for food influences non-subsistence production. Commercial farming is a business in which costs are incurred and in which debts must be paid. This situation is somewhat different from that of the tenant farmer who is constantly in debt to the land owner--a condition that is almost feudal in character and not particularly money-oriented. For commercial farming, the price factor must be involved in order to provide sufficient incentive for raising yields. On the other hand, the ability to reach peasants and raise productivity in the same way appears to be limited to a great degree.

Due to major differences between commercial and subsistence farming, it is often hard to deal with world production and yield estimates and projections. The potential for increasing commercial farm productivity in developing countries is often fairly good. If problems occur, they often involve market demand and costs rather than production. At the other end of the scale are the peasant farmers who have little association with the market economy. Apparently, the ability of nations to change this situation in the near future is somewhat limited. Between the commercial farmers and the pure subsistence farmers are those subsistence farmers whose operations have some commercial aspects. The ability to raise yields in this group is mixed but the potential in some cases is rather good if funds, training, transportation, irrigation, management, markets, and inputs can be established.

4.13 Substituting foods.--Figure 4-4 shows the degree of efficiency of converting feed to edible animal carcass, then converting to edible protein. Since animals are inefficient producers of calories, the United States has managed to increase yields in part by substituting vegetable for animal products. This includes production of a wide range of non-dairy product substitutes and the use of soybeans consumed in various forms. On the other hand, the potential for increased use of grazing land in developing countries may often be good if transportation is easily available. Thus, even though these types of operations may be extensive rather than intensive, such development should not be ignored in considering the possibilities of increasing output. Animal care and breeding and rangeland control could also raise production levels. The potential for increased trade through increased livestock production should be considered since products with high-income flexibility, such as beef, can serve as a welcome source of foreign exchange.

[87] Lester R. Brown. *Increasing World Food Output* (Washington, D.C.: U.S. Government Printing Office, 1965), p. 109.
[88] Ibid, p. 114.

Figure 4-4. CONVERSION OF FEED TO EDIBLE PROTEIN



Source: The World Food Problem, Volume II. A Report of the President's Science Advisory Committee. May 1967.

4.2 Multiple cropping

Multiple cropping is the cultivation of more than one crop on the same plot of land in one year. It is sometimes referred to as succession cropping (cultivating a crop then planting the same or another crop for harvest during the same year).

Multiple cropping must be considered separately from that type of farming which focuses solely on one crop per year. It may or may not raise yields per unit of area, but it does increase total production, total yield, and total area under cultivation.

The extent of multiple cropping is limited by physical conditions. Normally, it is found in irrigated areas and in areas with long growing seasons. It may also be part of the agricultural practices of areas with wet-dry climates. Rotation of summer crops and wheat in Mediterranean areas and kharif (wet) and rabi (dry) crops in India and Pakistan might serve as examples. Yield per crop in these cases may not be high, but total annual yield per hectare can be considerable. In India, for example, the output for non-irrigated areas is about the same as for irrigated areas. (However, low figures for irrigated areas may reflect inadequate facilities and inputs.)[89]

The amount of land involved in multiple cropping varies, but it is often over half of the cropland in some countries--such as Japan, South Korea, and Egypt. Multiple cropping is valuable not only because it increases output but also because it helps solve the farm labor problem to a degree. It provides more employment, helps reduce seasonal unemployment and under-employment, and makes fuller use of draft animals. In fact, supporters of multiple cropping maintain that it could create more employment for rural areas than industry.[90]

Multiple cropping requires efficient management as well as a favorable environment. Like other forms of agricultural development, it also involves the usual number of additional inputs (production of fertilizer, transportation, storage and marketing facilities). The attempt of the People's Republic of China to increase yields failed during the period of the Great Leap Forward in large part because such needed inputs were not available. It is sometimes suggested that each commercial farmer has a number of people working in non-agricultural sectors to help increase his output; without the non-agricultural contribution, the farmer's production would fall.

In calculating output, the economist Colin Clark refers to "standard land" units as a base. These units produce one crop per year. Drier or more humid areas are counted as more or less than one unit depending upon the degree of fallowing or the number of crops grown per year by means of multiple cropping. There are now 1.4 billion hectares of cultivated land. Applying a maximum coefficient to the tropics, Clark concludes that the earth has a potential of 10.7 billion hectares of standard land.[91] Another study estimates a

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[89] Dana G. Dalrymple. *Survey of Multiple Cropping in Less Developed Nations* (Washington, D.C.: U.S. Government Printing Office, 1971), pp. 68-69.

[90] Ibid, pp. 45-46.

[91] Colin Clark. *Population Growth and Land Use* (New York: Macmillan Co., 1967), pp. 143-144.

Country	Crop year					
	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73
PERCENTAGE OF TOTAL WHEAT AREA PLANTED IN HYV						
Asia:						
Afghanistan	1.0	5.2	6.2	10.7	13.3	18.4
Bangladesh	-	7.2	7.6	11.3	11.8	17.7
India	19.6	30.0	29.6	35.5	41.1	51.5
Iran	-	0.2	2.1	6.3	6.4	6.9
Iraq	0.3	2.0	9.6	9.0	45.2	22.9
Jordan	-	4.0	4.1	4.0	5.0	10.0
Lebanon	*	0.7	4.1	11.7	18.8	31.3
Nepal	12.9	25.9	33.5	43.0	50.6	65.8
Pakistan	16.0	38.0	43.0	52.3	56.7	55.9
Syria	-	-	-	4.3	6.8	21.2
Turkey	2.1	7.0	7.6	7.8	8.0	8.0[1]
Africa:						
Algeria	-	-	2.2	6.7	14.5	27.9
Morocco[2]	*	0.3	2.5	4.8	10.0	13.4
Tunisia	0.1	1.8	7.1	10.7	6.0	10.4
PERCENTAGE OF TOTAL RICE AREA PLANTED IN HYV						
Asia:						
Bangladesh	0.7	1.6	2.6	4.6	6.7	11.1
Burma	*	3.3	2.9	3.6	3.6	4.2
India	4.9	7.3	11.5	14.9	19.9	24.7
Indonesia	-	2.4	10.3	11.2	15.9	18.0
Korea (South)	-	-	-	-	0.2	15.6
Laos	0.2	0.3	0.2	6.0	3.3	5.5
Malaysia	20.6	20.1	26.4	30.9	35.7	38.0
Nepal	-	3.7	4.4	5.8	6.3	14.8
Pakistan	0.3	19.8	29.9	36.6	50.0	43.4
Philippines	19.8	30.4[2]	43.5	50.3	56.3	56.3[2]
Sri Lanka	-	1.0	3.9	4.4	4.2	2.5
Thailand[2]	-	-	0.1	1.5	4.0	4.9
Vietnam (South)	*	1.6	8.3	19.9	25.9	32.1

*Negligible.
[1]Based on 1971/72 HYV (high-yield variety) area.
[2]Based on unofficial estimates of HYV (high-yield variety) area.

Source: Development and Spread of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 95. July 1974.

maximum total cropped area of 6.6 billion hectares, if multiple cropping is counted.[92] Even if these figures are overly optimistic, it appears as if the potential for increased production through multiple cropping in some areas is favorable.

4.3 Green Revolution

There have been a number of impressive successes recently in developing high-yield varieties of certain plants. In the late 1960's, the term "Green Revolution" was created to describe a major achievement in increasing wheat and rice yields. The new seed varieties were particularly responsive to fertilizer, matured early, and did not fall very easily. Area planted in high-yield varieties rose rapidly in a number of countries, as shown in the accompanying table.

The output of wheat and rice production in these countries also was greatly raised. For example, India increased its wheat production from 11 to 27 million tons in the period 1965-72. As a result, despite later destruction due to the monsoons, India did not have to import as much wheat as it previously did. Similar advances were made in rice cultivation. The International Rice Research Institute in the Philippines experimented with seed which was later successfully used in a number of countries. The Philippines managed to become self-sufficient in rice for a short time. The result was that increased output permitted a longer period in which attempts could be made to decrease human fertility and bring the population-food ratio into better balance.

In spite of the advantages, many problems have been created by introducing miracle strains (high-yield varieties) of wheat and rice.

(1) The new seeds require an adequate and dependable source of water and large amounts of fertilizer. Thus, Turkish wheat farmers along the humid coast of that country

[92] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 434.

profited from introduction of the new strains, but farmers on the drier Anatolian Plateau did not.

(2) Although the new varieties could be used by all, the larger-scale farmers usually have the means to put them to better use. This is due to the fact that they have more resources available to them--funds, credit, instruction, services, fertilizer, and irrigation facilities. The subsistence farmer does not benefit particularly from the introduction of new seed. In fact, in some cases, land values rise and poor tenants become displaced.

(3) This point stems from the second. As has been mentioned, a wide range of services and inputs must be involved in improving overall farm conditions. Without them, only the prosperous farmer can gain from the introduction of a new seed variety, fertilizer, or other technological development.

(4) It has been difficult at times to transfer successfully the high-yield varieties to new physical and cultural environments. For example, new strains of rice have not adapted well to Indian climate and soils. Similarly, some varieties do not easily resist pest and disease attack. Regarding cultural factors, there are particular taste, cooking, color, and processing qualities that are not thought to be desirable characteristics in some countries. Therefore, some rice types were rejected in Asian countries; and Mexican red wheat varieties met resistance from users in India and Pakistan, who preferred amber-colored varieties.

In addition to new seed types, there are possibilities of increasing the geographic spread of certain plants. Hybrid corn will probably be adopted increasingly for use in Southeast Asia and in Kenya and other parts of Africa. Soybeans are being introduced into Venezuela and other tropical areas. Sorghums will doubtless also spread to a greater degree in semi-arid areas of the world.

Two conclusions should be drawn about the Green Revolution. First, despite many problems, production has risen in some countries and eased the food shortage. This is certainly a help to those countries trying to feed growing urban populations. Second, new technology in the field of farming can generally help only those who have land, capital, skills, and price incentives. The new wheat and rice seeds produce no more than the traditional varieties unless fertilized and irrigated. Thus they cannot be used readily by the poor subsistence farmer. As a result, there is a tendency for the rich farmer to become richer and the poor farmer to become poorer. Yet, as one study puts it, "The transition from traditional farming to modern agriculture will be difficult and expensive for the hungry nations, but it is absolutely essential if their food needs are to be met. There is no alternative."[93]

4.4 Marine husbandry

The oceans and inland waterways are sometimes regarded as major sources of food for the future. Estimates for total sustainable annual harvest from the sea range from under 100 million to about 2,000 million tons (compared with a present harvest of roughly 60 million tons).[94] Usually, the high estimates assume that means will be found to harvest forms of marine life which are presently untouched or under-utilized and are often far down the oceanic food chain. It is not clear whether an estimated 1- or 2-billion ton catch is actually feasible. As for the near future, it would appear that a well-managed and controlled world fishery might possibly yield up to 150 to 200 million tons by the year 2000.[95] Beyond this point, it is uncertain whether there can be an increase in catch without decreasing supply.

There are a number of unknowns regarding fish life. Estimates of fish catch are very uncertain; moreover, only several dozen out of thousands of species of fish are used by man, either directly or indirectly.

A great deal more information would have to be obtained about marine life and processes before an accurate assessment of its potential can be made. For example, areas of gushing of nutrient rich cold water to the surface encompass only 0.1 percent of the ocean surface; yet they furnish the

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[93] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. I, p. 19.

[94] Ibid, Vol. II, p. 346.

[95] S.J. Holt. "Food Resources of the Ocean," in *The Ocean, a Scientific American Book* (San Francisco, California: W.H. Freeman & Co., 1969), p. 100.

world with almost half of its fish catch. By contrast, 90 percent of the surface supplies only 1 percent of the catch; this area may or may not be a biological desert, but it is in large measure a statistical desert.[96]

Time and place of gathering of fish vary from year to year and the reasons for the differences are not clear. Yet, despite such conditions, the possibilities of overfishing are high. In the North Atlantic, for example, haddock and ocean perch stocks are down; salmon have all but disappeared; and cod have been fished beyond the point of maximum sustained yield.

Approximately 1/10 of the world catch is from inland waters and the remainder from oceans and seas. If data were available for subsistence fishing, the figure for inland waters would undoubtedly be higher.

Fish catch has increased by about 7 percent per year for the past decade. Despite this increase, recent catches of over 60 million tons supply only about 1 percent of the total world caloric intake and 10 percent of the protein consumed. Moreover, by the year 2000, it is anticipated that ocean areas could supply not more than 3 percent of the caloric requirements. The significance of the increase would lie mainly in the fact that it could produce about 1/3 of the world's protein requirements.[97] Presently over half of the harvest is consumed directly by humans and the remainder is processed into fish meal and used as fodder. Probably the proportion of the total world catch consumed directly by humans will increase somewhat in the future.

As might be expected, marine food is much more important in some areas than others. Fish makes up more than half of the daily animal protein consumption for about 1 1/2 billion people. This contrasts with the fact that 2/3 of the world's meat and milk supply is consumed by only 600 million people. Per capita intake of meat and milk is higher, however, than that of fish. Nevertheless, half or more of the animal protein consumed in Thailand, Indonesia, Portugal, and Japan comes from fish. The importance of fishing can perhaps be measured by the fact that for some countries the amount of arable land would have to be increased substantially if it were necessary to find a substitute for the protein now obtained from fish. For example, the percentage of additional arable land which would be needed to replace the protein from fish would be 120 for Jamaica, 113 for Taiwan, 75 for Belgium, and 59 for South Korea.[98]

Ocean farming on a large scale is not yet possible for a variety of reasons. As mentioned, there is a lack of knowledge about the biological processes in oceans. Furthermore, it is difficult to raise free-swimming species, such as tuna, which may have a range of hundreds of kilometers. It is assumed that this type of farming would not only involve breeding, but cultivation of feeding areas, including control of undesirable plants, pests, and disease. It would also doubtless require the enclosing of waters at river mouths and the movement of stock from breeding to fattening areas. This, in turn, would require some political agreements regarding fishing rights in open seas. Without certain safeguards, it is likely that little effort would be made to breed and fatten fish which live part of their lives in open waters and can be caught by anyone.

Lack of knowledge and lack of control of the open-sea zone has probably resulted in some overfishing in certain coastal and fresh water areas. Despite this, proper conservation measures could probably raise output considerably, particularly in inlets and marshes and in inland fisheries. Such areas are a major source of food. Swampland, for example, can at times supply more protein per hectare than comparable land used to raise domesticated animals. In addition, the protein potential from shellfish farming is very promising, provided

[96] G.B. Pinchot. "Marine Farming," in *Food*, ed. by J. Hoff and J. Janick (San Francisco, California: W.H. Freeman & Co., 1973), p. 242.

[97] W.E. Ricker. "Food from the Sea," in National Academy of Sciences - National Research Council, Committee on Resources and Man, *Resources and Man* (San Francisco, California: W.H. Freeman & Co., 1969), p. 87.

[98] Georg Borgstrom. "New Methods of Appraising the Role of Fisheries in World Nutrition," in *Economic Geography: Selected Readings*, ed. by F.E. Dohrs and L.M. Sommers (New York: Thomas Y. Crowell Co., 1970), p. 158.

pollution and problems of enemy attack can be overcome. Pond culture in inland areas sometimes produces yields of 30 to 50 tons per square kilometer, depending upon the species and area. Results are comparable to those obtained from grazing on fertilized pasture. Furthermore, the potential for expansion of area is good. For example, it is estimated that 37 million hectares of inland waters could be used for fish cultivation in the Indo-Pacific area alone.[99]

Fish may be fed on other fish, on grains, or on crop and animal wastes. About 1/4 of all paddy (wet rice) area is also used for fish cultivation. Since feed comes mainly from outside the pond, the figures for yields obtained (in kilos per hectare) may be slightly misleading. However, fish from flooded fields constitute an important supplemental source of food in Asia.

Some of the problems related to fish farming basically involve market considerations rather than sources of supply. Without refrigeration, quick freezing, and other processing techniques, and good distribution systems, the market would be restricted in area. Many inland areas, or regions distant from centers of supply, could not depend on fish as a source of food. Processing, transportation, and middle-man functions also would raise the price of the product and thus remove a large part of the market population that does not have enough purchasing power. Finally, taste and other considerations may also influence patterns of consumption.

4.5 New sources of food

Much research into new sources of food has taken place within recent years. Generally, this research falls into two categories. The first is concerned with ways to increase yields by use of complex agricultural techniques. The second concentrates on non-conventional, completely new sources of food. Each has promise, although problems of distribution and acceptance must be met.

Ways to increase production are being explored through experiments with the following: development of hybrid strains of plants without conventional bisexual pollination; cultivation of crops in saline soils; speeding up the process of photosynthesis; and growing crops in a liquid rather than on a soil base. Some investigation has also been undertaken to determine the possibilities of breeding certain wild grazing animals in marginal types of areas.

Work on new, synthetic sources of food is still mainly in the research stage. Experiments are being conducted to determine whether protein can be processed in digestible form and in sufficient quantity from certain plants, various types of leaves, and immature flowers. There is also some anticipation that wood pulp can, in the future, be converted into edible carbohydrates.

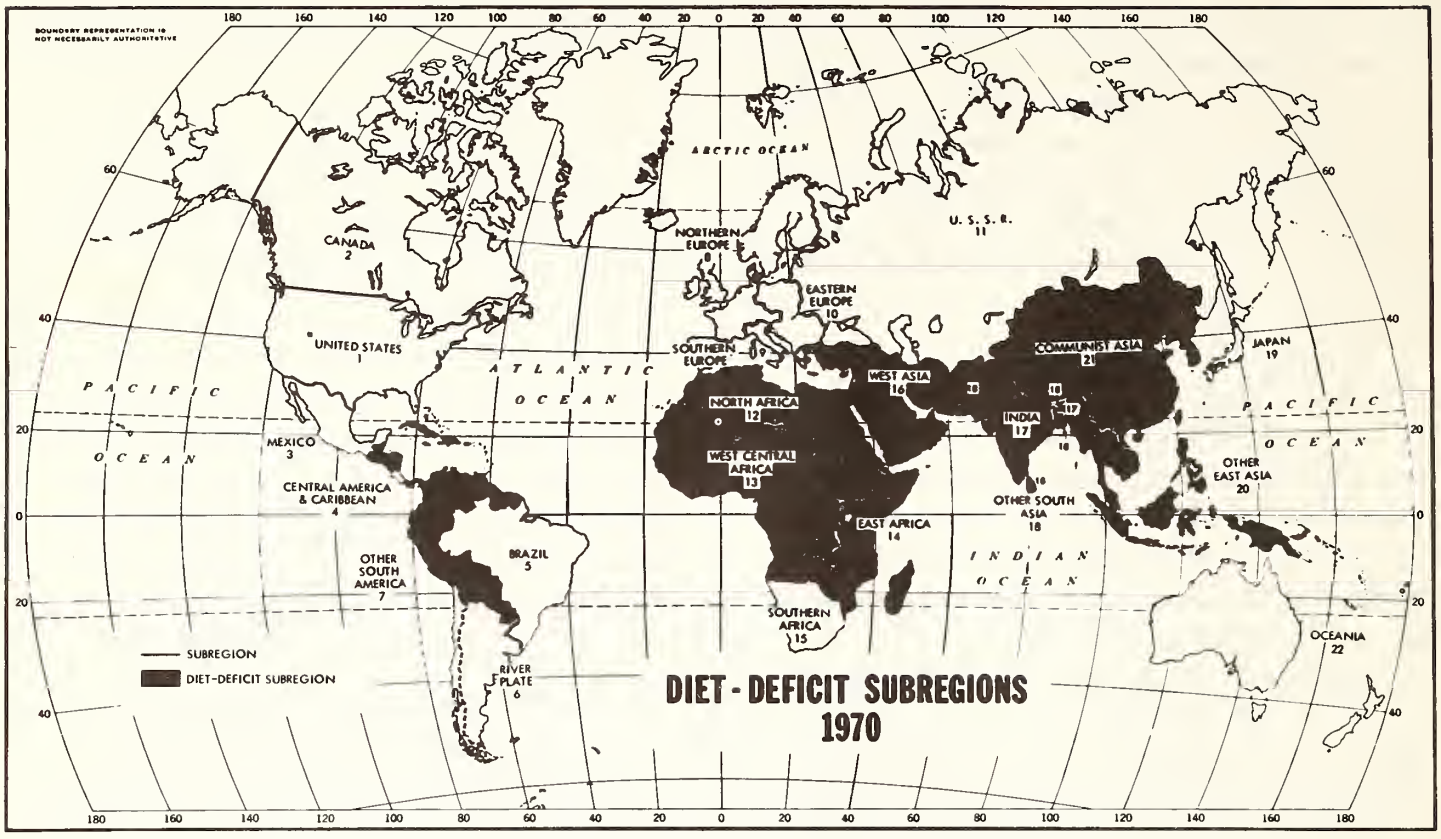
High-grade protein has been produced in the past few years by micro-organisms growing on a diet consisting mainly of petroleum hydrocarbons, methane gas, or cellulose. Generally, hydrocarbon and carbohydrate yields by weight of dry cell material are equal to or less than that of the original material. Because of problems created by energy shortages, this potential source of food may not be used in the quantities originally anticipated. Its merit lies partly in the fact that it can be produced without concern over the effects of climate and soil. The work is still experimental.

Fungi are apparently not particularly suitable as sources of protein, and the use of algae is restricted because of costs, digestibility, and toxicity. Nevertheless, yeast and bacteria may have some potential. It is calculated that 450 kilos of yeast can produce 100,000 tons of protein in 24 hours, whereas a steer weighing 450 kilos can add only 0.4 kilos of protein within the same time.[100] This work, too, is in the experimental stage.

[99] U.S. Department of Agriculture. *The World Food Budget, 1970* (Washington, D.C.: U.S. Government Printing Office, 1964), p. 69.

[100] Hans H. Landsberg. "Population Growth and the Potential of Technology," in *World Population--The View Ahead*, ed. by R.N. Farmer, J.D. Long, and G.J. Stolnitz (Bloomington, Indiana: Indiana University Press, 1968), p. 156.

Figure 4-5. DIET-DEFICIT SUBREGIONS: 1970



Source: The World Food Budget, 1970. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 19. October 1964.

There are two major problems regarding development of new foods. First is the matter of cost. If the cost is high, then the developing nations would not be able to afford it. Second, the research and experimentation in processing techniques are carried out mainly by the developed countries. This presents some difficulty in transferring the findings and technology in an acceptable manner to nations with somewhat different physical and cultural conditions.

4.6 Nutritional needs

The United Nations Food and Agriculture Organization estimates that 20 percent of the population in developing countries are undernourished (have too little food) and 60 percent of the population are malnourished (eat the wrong types of food). Colin Clark, the economist, disagrees with these calculations.[101] The point, however, is that while data may not be reliable, large numbers of people either lack sufficient food or are on imposed diets that are qualitatively deficient (see figure 4-5).

Hunger and improper nourishment retard productivity and economic development. They contribute to high mortality rates, reduce resistance to disease, reduce the capacity to work, and can result in reduced mental efficiency and in emotional and personality problems. Children apparently obtain lower scores in intelligence tests as a result of under-nourishment. Little apparently can be done in later life to repair brain damage sustained by poorly nourished children.

It is misleading to think of nutritional needs only in terms of calorie and protein requirements. Vitamin A, the complex of B vitamins, vitamin C, plus other vitamins and minerals all are important and necessary ingredients in a well-balanced diet. For example, deficiency diseases are often the result of a lack of vitamins in tropical Africa.

[101] Colin Clark. *Population Growth and Land Use* (New York: Macmillan Co., 1967), p. 124.

Data for nutritional evaluation are not as useful as they could be because they focus on agricultural production rather than consumption. As a result, food surveys often lead one to believe that protein shortages in some countries should not exist. These data, however, do not usually consider food intake, which may be lower than production per capita due to various types of losses and waste. Moreover, if the output appears adequate, it is then often wrongly assumed that additional food should be shipped into areas with actual crop shortages or failures. The effects of poor or inadequate storage, lack of transportation, and unequal distribution are thus not always taken into account. As would be expected, there are wide differences in food intake by area, and also by income class; these differences are not reflected in national production averages. (See figures 4-6 and 4-7 for country averages.)

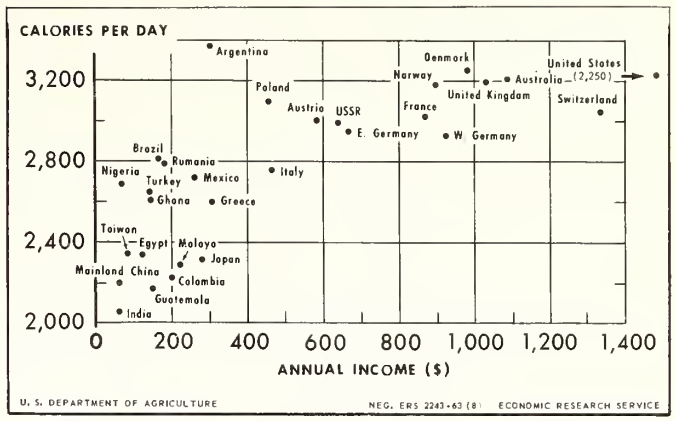
Food and nutrition demands vary according to age, sex, stature, and climate zone. For example, children, pregnant women, and nursing mothers need proportionately more protein than the average person; the average Indian weighs 15 percent less than the average Malaysian, and the average Vietnamese weighs 40 percent less than the average Uruguayan; people in sub-Arctic areas require a higher percentage of fat in their diets than people in temperate zones. There is, however, some controversy over the impact of temperature. Some claim that caloric intake in the tropics, for example, should be increased rather than decreased, because of the higher energy cost of work.[102]

It is difficult to measure or compare caloric and nutritional needs on the basis of intake in many developed countries. This is due mainly to widespread over-eating in those areas. Therefore, standarized averages necessarily would reflect what is considered normal within a specific region or country.

Food consumption is governed not only by its availability, but also by custom and taste. Most people do not clearly understand human nutritional needs and therefore may not challenge traditional methods of food preparation or try to improve the quality of their diets. Accordingly, food supplements must be in a form and flavor which people will accept. It is also desirable to avoid presenting the new food as a specialized product to be consumed only by the poor.

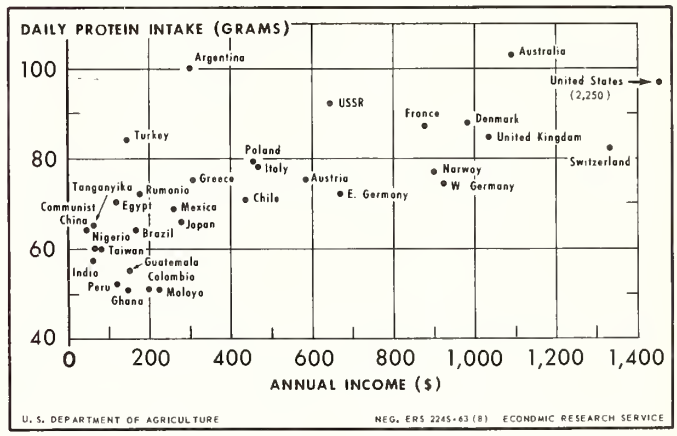
Cereals provide over half of the per capita average energy intake in the world. The remainder is divided evenly among livestock products, fruits and vegetables, potatoes and other tubers, animal fats and vegetable oils, and sugar. Nutritional deficiencies are particularly serious in those countries where single foods provide the main source of food energy.

Figure 4-6. INCOME AND FOOD ENERGY SUPPLY PER PERSON



Source: Man, Land, and Food. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 11. November 1963.

Figure 4-7. INCOME AND TOTAL PROTEIN SUPPLY PER PERSON



Source: Man, Land, and Food. U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 11. November 1963.

[102] President's Science Advisory Committee. *The World Food Problem* (Washington, D.C.: U.S. Government Printing Office, 1967), Vol. II, p. 46.

Probably one of the most critical elements in a balanced diet is the amount of protein consumed. For example, the average male requires a protein intake of about 14 percent of his food consumption.

The protein content in plants is surprisingly large. Annually throughout the world, about 20 million tons of protein is left as residue after oil is extracted from soybeans, peanuts, cottonseed, and sunflower seed; this is twice the world's current protein deficit. Peas, beans, and soybeans contain fairly high proportions of proteins. Nevertheless, plant proteins do not have an amino acid type of composition necessary for human needs. For this reason, lysine enrichment of corn, which involves a high amino content, may help solve the problem in the future. At present, cereals provide 70 percent of the total available protein to persons in developing countries.

Meat, dairy products, fish, eggs, and poultry are prime sources of essential amino acids. The major problem is to find some way to provide protein derived from these sources to populations in developing countries. One solution is fish protein concentrate, which can be used as a protein additive. However, a large investment is necessary for plant and machinery, and there is some loss in quality of product during processing. Adding nutrients to cereal grains is cheaper, although the product cannot supply all of the protein needs of children. Incaparina, a protein supplement in powder form, is marketed successfully in Latin America.

The search is thus continuing. It seems fairly certain that, whatever the technological success, each nation will have to adapt to it in its own way and find its own means to distribute the new products equitably and uniformly.

5. SUMMARY

The concept of a resource is often vague. A resource is defined as such only if it is so identified and used by man. Use, in turn, depends upon the available technology and on man's perceptions and motivations--economic, social, and political.

It is normally not possible to determine the degree of balance between population and resources within an area using optimum population concepts and density measures. This is because many of the factors involved are difficult to evaluate and are often subject to judgment. Nevertheless, use of the concept and the measures persist since there is a felt need for some evaluation of this kind.

There are several ways in which the resource balance regarding food can be corrected. Extension of the agricultural area is not always as effective or productive as are efforts to raise yields or increase the amount of multiple cropping within an area. However, each country must determine its own policy in this regard. Advocates of raising yields by means of some type of Green Revolution technique should be aware that any new technological device is basically no better than the people who use it. In other words, the new knowledge and material can be used effectively mainly in an area which is economically, socially, and politically receptive to it. For this reason, the wealthy, large-scale commercial farmers generally are able to benefit from high-yield varieties to a greater degree than are the subsistence farmers. Marine farming and new sources of food may add to world food supplies, but these sources are limited by such factors as depletion, costs, customs, and inability to distribute new products uniformly within countries. Lastly, more research and data are necessary on nutritional needs and food consumption. Without such information it is difficult to measure specific nutritional needs.

The objective of this document has been to put man and his agricultural base into proper perspective. This is a complicated matter, and the problems that were presented do not have easy or simple solutions. Louis Pasteur, the French scientist, once said that, "He who only possesses clear ideas is assuredly a fool."

The attempt here was not to highlight problems and criticize any solutions, but rather to point out that new scientific and technological endeavors should not be looked upon as anything more than a means to be used in reaching an objective. More often than not, the innovations must fit into a forced pattern, rather than vice versa. In other words, the innovation must be adapted to the environment and culture into which it is introduced. Thus Simon Kuznets, the economist, very pointedly argues that the technological ability to increase agricultural production has to be closely linked to the political, social, and economic institutions of the area.[103]

In accordance with this discussion, it also should be noted that, although time is very important, it seems improbable that most nations can achieve a better population-food balance quickly. New technologies can be introduced quickly, but institutional changes take more time.

Similarly, it can be pointed out that new ideas should be adapted to the physical as well as to the cultural environment. People's perceptions, adaptation to ecological limitations, use of land area to raise yields, and development of new arable areas must be based on an intelligent understanding of the relationship between nature and man.

For many of the developing nations, the focus of the attempts to correct the population-resource imbalance has involved a concentration of effort on some form of population control and on increasing agricultural production. This does not necessarily mean that all nations particularly favor population control, or that improvement in agriculture has been the only objective in their efforts at economic development. Nevertheless, a major attempt has been made by many countries to improve their status by directly attacking the problems arising from an unbalanced man-food ratio. The task is a difficult one and the results may not always appear to be proportionate to the need.

In dealing with the problem, there is an unfortunate tendency to separate the efforts into categories, despite the fact that population growth and food supply are closely related. A major program of agricultural development certainly should consider population factors. Focusing on the agricultural problem in rural areas without considering local population aspects would be as misleading as concentrating on population problems in urban areas without considering how agricultural production can affect city life.

An attitude that arises in the attempt to improve the population-food balance is the tendency for people to think that their personal decisions count for very little. In both family planning and in farm improvement programs, people must somehow be convinced that their individual actions, when taken together, can make the effort a success or a failure. For this reason, continuing information and publicity campaigns should be considered to be important parts of the program.

Finally, the point should be made that the developing countries are faced with the need to develop their own resources. It is unlikely that imports of food can at all times supply the major portion of the needs of the hungry nations.

The goal of this document has not been to develop and suggest solutions to the many problems of population and land pressure in the world. Its objective, in a small way, is to provide the reader with an informational framework which he can use in evaluating environmental, population, and agricultural problems. This objective assumes that such a framework is a necessary characteristic of competent and effective decision-making.

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[103] Simon Kuznets. "Economic Capacity and Population Growth," in *World Population--The View Ahead*, ed. by R.N. Farmer, J.D. Long, and G.J. Stolnitz (Bloomington, Indiana: Indiana University Press, 1968), p. 84.

DISCUSSION TOPICS

Chapter 1. MAN AND THE LAND

1. In 1968, Brazil announced its intention to develop the huge Amazon rainforest region so it would become the "breadbasket" of the world. What ecological changes might result from this development? How could these changes be controlled?

2. Historically, the British have been considered to be a nation of seafarers. Accordingly, they have been said to have a maritime outlook. Some explain this behavior by the fact that the British live on an island. The Irish, however, have not been very sea-minded; nor have the Japanese been consistent in regard to their orientation to the sea. What influence does a country's location have on its people? What factors might outweigh that influence?

3. Assume that the common boundary line between two neighboring countries runs down the middle of the main stream of a river basin that has great potential for development. What factors must be considered to achieve an efficient development of the area?

4. At a United Nations conference on the environment, some participants maintained that developing countries trying to industrialize cannot make pollution control a primary goal when so many of their people are poor and hungry. What logical arguments can be made to oppose that view? Is the issue necessarily an "all or nothing" proposal? How is pollution defined?

5. Huge sums of money continue to be invested in the construction of dams throughout the world. What are some of the ecological problems associated with dams? Can building of dams be justified?

Chapter 2. POPULATION FACTOR

1. Many rural population concentrations are found in areas that do not have particularly fertile soils--in sub-Saharan Africa, for example. Why would people locate and remain in such areas?

2. A former president of Brazil, in urging the establishment of a new inland capital city and the development of frontier areas, wondered why so many people along the coast continued "to stare fixedly at the sea, as if they were planning to depart." What kind of social and institutional problems might be faced in urging people to move into frontier zones? What type of assistance is needed to support new settlers in such areas?

3. Describe the extent of the "city region" around the capital of your country. How would the boundary of this city region be determined?

4. What is a rural population? What criteria would be used to define "rural"? Compare the numbers and the characteristics of the rural population in your country with the rural of other countries.

5. What effective measures could be taken to slow down the migration from rural to urban areas?

6. Why is the ecumene (area of the largest concentration of population) in most countries located close to the coast?

Chapter 3. AGRICULTURE

1. What area in your country has the best potential for attracting agricultural processing industries? Why? What steps are being taken to realize that potential?

2. Consider this statement: "Agrarian reform infers a drastic revision in the patterns of income distribution, political power, and social hierarchial order within a country." What arguments can be made to support this statement? What arguments can be made against it?

3. How can subsistence farmers be converted to commercial farmers? How could these steps be implemented in your country?

4. What difficulties arise when developing countries attempt to increase the use of fertilizer? How can these problems be resolved?

5. Developing nations should make greater efforts to control the production and prices of the agricultural commodities they export. What are the difficulties involved in achieving this goal?

6. Compare industry and agriculture in terms of (a) space required for operation; (b) seasonality of the work cycle; (c) control over production; and (d) size of production units.

7. What are the goals of an active, involved agricultural extension service? What type of assistance would be provided by the service? What kinds of people does it serve?

Chapter 4. POPULATION-FOOD BALANCE

1. Why are the techniques involved in multiple cropping not exactly the same as those used to increase yields?

2. In some areas, the miracle strains (high-yield varieties) of rice and wheat have increased the output of these grains substantially. What problems and setbacks have been met by supporters of the Green Revolution?

3. Would it be reasonable to exclude arithmetic density calculations from a series of statistical tables describing your country?

4. How would the optimum population be calculated for your country? What methodology would be used? Would this estimate be accepted by most analysts?

5. Which would be the better way to increase agricultural production in your country--increase yields or extend the cultivated area? Explain the reasons for your choice.

GLOSSARY OF TERMS

Accessibility: That characteristic of a location which permits the easy flow of people and goods between places. Many of the frontier areas of the world, for example, may have very desirable qualities insofar as agricultural land use is concerned. However, because they are hard to reach, due to physical barriers and the high cost of transportation, they are not intensively used. Generally, the ecumene areas are accessible and non-ecumene areas are not accessible.

Agglomerated (or clustered) settlement: Concentration of people living close to each other, under fairly high density conditions.

Agrarian reform: An attempt to improve agricultural conditions. The term is used often to refer to land redistribution, but it should also include those other inputs needed to increase and improve production, yields, and farm life in general.

Agricultural density: The number of persons engaged in agriculture per square kilometer of arable land. The agricultural population may refer to the total figure or to various segments of it. For example, density calculations could be made for the number of males in agriculture, the number of tenants, the number of dependents of farmers, etc.

Arable: Land which is considered suitable for cultivation. The concept of arable may be subjective; some people may believe a certain area to be arable, whereas others may not.

Arithmetic density: Persons per square kilometer of land. Since this calculation does not attempt to evaluate population characteristics or the quality of land, its value as a measure of the relationship between people and resources is limited.

Artesian flow: Water flowing in sloping porous rock from a humid area to another area which is lower in elevation. Wells can be drilled in the lower area and water will then flow up to the surface without pumping. Large artesian basins are a major source of water in a number of dry areas in the world.

Calcification: A soil process associated with arid (dry) or semi-arid areas. The drier climate permits accumulation of soil nutrients (including calcium compounds) in certain cases. However, under other conditions, alkali content of soils may be too high for proper plant growth. Accordingly, calcified soils vary from very poor to very fertile areas for cultivation.

City region: An area extending beyond the suburbs surrounding a city. Both the functions and activities of the region are closely related to those of the nearby city. Such an area therefore services the city and uses it as a market place and source of employment. Many of the economic, social, and political characteristics of life in the city region are urban in nature, because of the region's close relationship to the city which it surrounds.

Commercial farming: Production of agricultural goods for sale. Almost all the necessary fertilizer, fuel, and equipment is purchased; the variety of crops grown is smaller than that associated with a subsistence farm. Products may often enter into national and international trade channels.

Density: Relationship between man and his resource base. Various measures of density are used, with varying degrees of success (arithmetic, physiological, agricultural, urban, economic, optimum). The most useful types, such as economic or optimum density, are the most difficult to calculate. Accordingly, density measures should be used with great care.

Dispersed (or scattered) settlement: No large concentration of people at any one point.

Ecology: The study of the relationship of living organisms to their environment and to each other.

Economic density: The comparison of people and resources. It is not related directly to the size of land area, but rather to the amount and quality of the resources and the skills and capabilities of the population. Economic density is a difficult measure to calculate and is therefore considered useful only in a theoretical sense.

Economies of scale: Benefits which are obtained from a large-scale operation. Because of its size, such an economic activity involves production, transportation, and sale of a large number of items. Such an activity can therefore obtain or sell items at lower costs per unit.

Ecosystem: Shortened term for "ecological system." It refers to the manner in which the organism-environment relationship works.

Ecumene: That part of a country where one finds the largest concentration of population, the greatest economic activity, and the most intensive land use.

Edible: Anything fit to be eaten. Different peoples and cultures may vary widely in terms of what they consider edible. For this reason, introduction of a new type of food into a society may not always result in ready acceptance by the people who were to benefit from it.

Environment: All the conditions, circumstances, and influences surrounding and affecting man and his activities.

Erosion: The wearing away of soil, subsoil, or bedrock by natural means or by man-made activity. Thus, agents of erosion include man as well as such natural forces as running water, wind, waves, and ice. Poor agricultural practices have created major erosion problems in many parts of the world resulting, among other things, in the loss of large amounts of valuable top soil.

Estuary: An inlet or arm of the sea. It particularly refers to the wide mouth of a river where the tide meets the river current. It is an important breeding ground for certain types of fish and fowl.

Evapotranspiration: The measure of the amount of moisture involved in evaporation and transpiration (water loss of vegetation).

Extensive farming: Agriculture often associated with large holdings, mechanization, labor shortages, and no land pressure. Yields per hectare are low, but yields per man are often fairly high. Wheat farming in the Canadian prairies can be mentioned as an example of extensive agriculture.

Intensive farming: Agriculture often associated with small plots and a considerable input of labor, fertilizer, and other ingredients. Yields per hectare are often high. Irrigated paddy farming in Asia may be mentioned as a good example of intensive agriculture.

Laterization: A soil process associated with humid tropical areas. Soils tend to be low in organic material and plant nutrients; these soils generally should be fertilized often and lightly in order to be productive.

Malnourished: Lack of proper nutrition. Persons who are malnourished may have a total caloric intake that is sufficient, theoretically, to meet their energy needs. However, their food balance is poor; for example, they may be consuming too many starchy foods on the one hand and too few foods with a high protein content on the other hand.

Mechanization: Use of machinery in agricultural operations. The machinery may be powered by animals or by engines. While introduction of machinery into an agricultural area may displace labor and create unrest, it is also a means by which yields can often be increased substantially.

Multiple cropping: Growing of more than one crop in succession on the same plot of land during the agricultural year. This type of farming is possible in areas with irrigation or sufficient rainfall and with a long growing season. Many tropical and arid areas, if irrigated, thus can produce two or more crops each year.

Nonecumene: That part of the country which has a small population and is less intensively used than the ecumene. For the most part, the nonecumene covers a much larger land area than the ecumene region.

Optimum density: The ideal density for a given area according to the skills and quality of its population and resources. It refers to the maximum number of people which an area can support under a given set of living standards. It is difficult to calculate and is therefore usually referred to only as a vague and theoretical figure to be used for planning purposes.

Optimum population: The determination of the most desirable balance between the number of people and the resources available for their use. Areas which are poor in resources and have large populations are considered overpopulated; those with small populations and a large resource base are said to be underpopulated. Calculation of an optimum figure is difficult, but it is a useful theoretical measure to help set national goals regarding population size and development of resources.

Organized agricultural development: System requiring a major planning effort and capital input on the part of a government. Farming in such an area is commercial in character. Critics of this type of development point to the high costs involved; some defenders of these programs suggest that these costs can be substantially reduced. One of the keys to success of organized agricultural development involves the cost of transportation.

Paddy: A type of irrigated holding in Asia associated with rice cultivation. It is a successful form of agriculture that requires good social and administrative management.

Perception: The way in which man sees or thinks about his environment. This may not always coincide with the actual way in which the environment operates. As a result, environmental mismanagement may take place.

Physiological density: The total population per square kilometer of arable land (sometimes referred to as nutritional density). This measure presumably should indicate the degree of dependence on foreign sources of food. Thus, if the density figure is high, it is assumed that agricultural products must be imported into the area.

Podsolization: A soil process associated with cool to cold humid climates. Soils are acidic, but can often be very productive if properly managed.

Pollution: The addition of impurities into water bodies, rivers, and the atmosphere, mainly as a result of man's activities. Some experts claim that the unrestricted use of fertilizers, herbicides, and insecticides has a bad effect on water quality and that some forms of man-made erosion and the burning of vegetation can result in poor air quality.

Prairie: A grassland of the mid-latitudes. The grass is fairly tall and rich in nutrients. The area may be used for grazing or cropping or for both activities. The climate varies from semi-arid to humid in such areas.

Resource: Something that man recognizes as useful. The term is sometimes broadly interpreted as referring to people (human resources), but it is not used in this way in this document. Resources may include living as well as non-living objects; thus, vegetation types such as forests are regarded as resources, as well as minerals and water.

Savanna: A grassland of the tropics. It is associated with a wet-dry season and is used mainly for grazing purposes. During certain seasons, the grass may be less nutritious than that found in the prairie.

Selva: A humid tropical rainforest. The large variety and mixture of species of trees have made this type of forest difficult to use commercially.

Spontaneous agricultural development: System involving settlement of new lands for farming with little official assistance or control. This type of settlement and land use very often is associated with subsistence (or non-commercial) farming.

Steppe: A grassland of the mid-latitudes. The climate is semi-arid, the grass is short, and the area is generally used only for grazing purposes. If the steppe is cultivated or overgrazed, dust bowl conditions may develop.

Subsistence farming: Farm operations which are not primarily commercially oriented. Farm types vary from those in which nothing is sold off the holding to those in which certain crops may, at least in part, be grown for market. Subsistence farms are often located in areas with poor transportation facilities, and for this reason may not be commercially oriented.

Sustained yield: A concept applied to renewable natural resources such as forests and fisheries. Harvest and replacement must be balanced over a period of time so that yields will continue indefinitely.

Transpiration: The loss of moisture by plants. For some plants, the transpiration rate is even greater than the evaporation rate of open water.

Urban density: Persons per square kilometer in urban areas. It is calculated exactly like crude or arithmetic density and is used in urban planning work.

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